Five-Year Synthesis Report of the PSC Coded Wire Tag (CWT) Improvement Program

Pacific Salmon Commission Joint CWT Implementation Team

February 2015

Pacific Salmon Commission Technical Report No. 33

The Pacific Salmon Commission is charged with the implementation of the Pacific Salmon Treaty, which was signed by Canada and the United States in 1985. The focus of the agreement are salmon stocks that originate in one country and are subject to interception by the other country. The objectives of the Treaty are to 1) conserve the five species of Pacific salmon in order to achieve optimum production, and 2) to divide the harvests so each country reaps the benefits of its investment in salmon management.

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List of Acronyms and Abbreviations

AABM	Aggregate Abundance Based Management
ADF&G	Alaska Department of Fish and Game
Agreement	June 30, 1999 PST Annex and the Related Agreement
BC	British Columbia
CBC	Central Coast British Columbia (Kitimat to Cape Caution)
CoTC	Coho Technical Committee
CRC	Catch Record Card (WDFW)
CRITFC	Columbia River Intertribal Fish Commission
CTC	Chinook Technical Committee
CWT	Coded Wire Tag
CWTF	ODFW CWT database application
CWTIP	Coded Wire Tag Implementation Program
CWTIT	Coded Wire Tag Implementation Team
DFO	Canada Department of Fisheries and Oceans
DIT	Double Index Tag
ER	Exploitation Rate
FN	First Nations
FOS	Fisheries Operating System (DFO)
HG	Haida Gwaii
ISBM	Individual Stock Based Management
LFA	Lower Fraser Area
LFFA	Lower Fraser Fisheries Alliance
LOA	Letter of Agreement (US)
MOU	Memorandum of Understanding accompanying the 1985 PST
MSF	Mark Selective Fishery
NBC	North Coast British Columbia (Dixon Entrance to Kitimat including Queen Charlotte Islands)
NCBC	North Coast British Columbia (Dixon Entrance to Kitimat including Queen Charlotte Islands) and Central Coast British Columbia (Kitimat to Cape Caution)
NMFS	National Marine Fisheries Service
NWIFC	Northwest Indian Fisheries Commission
ODFW	Oregon Department of Fish and Wildlife
ONA	Okanagan Nation Alliance
PBT	Parental Based Tagging
PSC	Pacific Salmon Commission
PSE	Percent Standard Error
PST	Pacific Salmon Treaty
QIN	Quinault Nation
SEAK	Southeast Alaska Cape Suckling to Dixon Entrance
SWVI	Southwest Vancouver Island
TR 25	PSC Technical Report 25
US	United States
USFWS	US Fish & Wildlife Service
WCVI	West Coast Vancouver Island excluding Area 20
WDFW	Washington Department of Fish & Wildlife

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EXECUTIVE SUMMARY

Coded Wire Tags (CWTs) remain the only available tool that is capable of providing the information required to support PSC management regimes for Chinook and Coho salmon. Under the 2009 Pacific Salmon Treaty (PST) agreement, each of the Parties agreed to provide $7.5 million in their respective currencies over a five year period to undertake a Coded Wire Tag Improvement Program (CWTIP) for Chinook salmon. A bilateral Coded Wire Tag Implementation Team (CWTIT) was established by the Pacific Salmon Commission (PSC) to provide recommendations for use of CWTIP funding.

CWTIP funded projects are tabulated in Section 2. Each project addressed deficiencies in the CWT program noted in PSC Technical Report 25 (PSC 2008). Examples are provided to illustrate short- intermediate and legacy benefits.

Improvements in the CWT system, however, cannot be sustained unless adequate, stable funding is provided for a core CWT system of tagging, sampling, enumeration, processing, and reporting. Although specific requirements for a core CWT system have not been developed, the annual cost for maintaining improvements to the CWT system for Chinook salmon realized under the CWTIP is estimated to be $1M to $1.5M.

The CWTIT recommends that the PSC directly support regular assessments of the ability of the CWT system to provide the information required for implementation of PST fishery regimes, as well as to support future negotiations of the PST.

1 Introduction

In adopting the 1985 Pacific Salmon Treaty (PST), the United States and Canada recognized the need for comprehensive stock and fishery assessments in the assignments to the various bilateral technical committees in the chapters contained in Annex IV. The Parties explicitly recognized the seminal importance of maintaining a coded-wire-tag (CWT) system in Section B of the *August 13, 1985* Memorandum of Understanding that accompanied the PST agreement:

> *The Parties agree to maintain a coded-wire tagging and recapture program designed to provide statistically reliable data for stock assessments and fishery evaluations.*

A coast wide system to coordinate the tagging, recovery, and reporting of CWT release groups was established in the late 1970's to enable agencies to determine stock and fishery specific exploitation rates, survival rates, complete stock assessments, and evaluate management performance. The agreement included sequestration of the adipose fin clip to indicate that a fish contained a CWT in order to minimize the number of fish that had to be processed to recover CWTs.

For almost 40 years the CWT system has provided a practical and efficient means for coast wide assessment and fishery management of Chinook (*Onchorynchus tshawytscha)* and Coho salmon (*Onchorynchus kisutch)* because it:

1) includes fully integrated tagging, sampling, and recovery operations along the entire west coast of North America;
2) has sufficient resolution for stock-specific assessments;
3) provides a standardized method of analysis of stock and fishery assessments; and
4) permits the evaluation of trends in stock and fishery statistics such as survival indices and brood exploitation rates.

In response to concerns related to increasing uncertainty around CWT based estimates the PSC established an Expert Panel to conduct a review of the CWT program in 2004. The Report of the Expert Panel on the Future of the CWT Recovery Program for Pacific Salmon (PSC 2005) identified increased uncertainty around CWT based estimates due to:

1) Reduced recoveries of CWTs from fisheries as survival rates declined and fishery impacts were reduced;
2) Reduced sampling rates resulting from fiscal constraints;
3) An increasing proportion of the catch taken in recreational fisheries with lower sampling rates than commercial fisheries; and
4) Shifts to alternative management measures such as non–retention and hatchery mark selective fisheries and increased complexity of management requiring estimates at finer scales of fishery-time/area resolution.

In its report, the Expert Panel concluded: *No other practical mark-recovery system has yet been devised that is capable of providing this level of detail in such a timely fashion. The historic success of the CWT program has been in no small part due to the high level of coordination and cooperation among the coastal states and British Columbia and to the consistency of CWT tagging and recovery efforts across the many political jurisdictions. Despite the emergence of other stock identification technologies, including various genetic methods and otolith thermal marking, the CWT tag recovery program remains the only method currently available for*

estimating and monitoring fishery impacts on individual stocks of coho and chinook salmon for implementation of fishing agreements under the Pacific Salmon Treaty (PST).

The review by the Expert Panel provided 15 recommendations categorized as:

- Correcting current deficiencies in CWT system (recommendations 1-5);
- Responding to Mass-marking and Mark-selective fisheries (recommendations 6-8);
- Developing a coordinated research and implementation plan (recommendations 9-14);
- Considering new management paradigms (recommendation 15).

In response to the Panel's recommendations, the PSC appointed a CWT Workgroup to develop recommendations to correct deficiencies in data collection and reporting throughout the CWT program and to improve analysis of CWT recovery data. The Workgroup determined the highest priority was to develop options to address Expert Panel Report Recommendations #1-4. The Workgroup reviewed the tagging and sampling programs, the data collection, validation, and reporting of agencies releasing and sampling tagged Chinook and Coho salmon coast wide and identified both the issues and solutions to address specific problems in Technical Report Number 25 (TR 25; PSC 2008).

The current Chinook and Coho annexes of the PST are directed at constraining exploitation rates on naturally spawning stocks in order to provide a means for sharing harvest and conservation responsibilities. The Chinook Technical Committee (CTC) and Coho Technical Committee (CoTC) which are charged with assessing the implementation of these annexes rely on CWT data to complete the analyses required to implement PST fishery regimes. These analyses depend upon the coast-wide CWT system to provide data to estimate age- and fishery-specific exploitation rates from hatchery indicator stocks that are believed to be representative of exploitation rates and patterns of associated naturally spawning stocks. The coast wide CWT program encompasses a coordinated system of CWT indicator stocks, statistically-based fishery and escapement sampling programs, catch and population estimation programs and data reporting and sharing standards (Johnson 2004; PSC 2005). The foundation of the coast wide CWT program (Figure 1.1) is based on the annual release and recovery of tagged hatchery- or naturally-reared juveniles from the suite of CWT indicator stocks.

Estimates of CWT recoveries in fisheries and escapements provide the data to implement and evaluate the PST fishery regime for Chinook. The estimates allow determination of the range and timing of ocean migration, prevalence in fisheries and are used in assessment of stock-specific conservation obligations defined for each Party to the PST. Quantitative analysis of the CWT recoveries through cohort analysis generates a variety of statistics by stock, brood, age and fishery. These statistics are used to track temporal patterns in mortality and maturation, to assess total fishery impacts by each Party and to generate abundance forecasts by the PSC Chinook Model for the purpose of setting allowable catches in major mixed stock fisheries. Benefits of the data generated by the coast wide CWT program to Canada and the US include regulation of fishery impacts and conservation of wild stocks, setting of abundance-based allowable catches in fisheries where many co-migrating stocks are encountered and age-specific abundance forecasts. Improvements to the coast wide CWT program provide a sound basis for implementing the abundance-based Chinook management regime outlined in Chapter 3 of the 2009 PST Agreement.

Because the CWT system is central to the ability to implement the 2009 PST Chinook Agreement, the Parties agreed to provide $7.5 million each in their respective currencies over a

five year period to implement critical improvements to the CWT programs operated by their respective management agencies (Annex IV, chapter 3, paragraph 3(b)).

The goal of this coordinated bilateral CWT improvement program (CWTIP) was to improve the precision and accuracy of essential data and statistics used in the management regime for Chinook salmon by Canada and the United States (US). The PSC established a bilateral body, the Coded-Wire-Tag Implementation Team (CWTIT) to provide recommendations regarding the projects to be funded through the CWTIP (Pacific Salmon Commission 2008) and to coordinate implementation to optimize the benefits of the CWT programs operated in the various jurisdictions. The Terms of Reference for the CWTIT provide further details in Appendix A.

Canada implemented the program in 2009, a year earlier than in the US due to differences in the beginning of the fiscal years. The final year of funding for this initiative was 2013-14 in Canada and 2014-15 in the US.

The US solicited proposals through a Request for Proposal process annually. Proposals were ranked independently by US CWTIT members and subsequent final ranks were reached by consensus, to provide recommendations. These were relayed to Canada for comment and then forwarded to the US PSC for final consideration. Canada developed their recommendations through an internal process that identified projects to address high priority issues identified in TR 25 Recommendations #1-4. The recommendations were shared with the US CWTIT for comment before forwarding to the PSC for consideration.

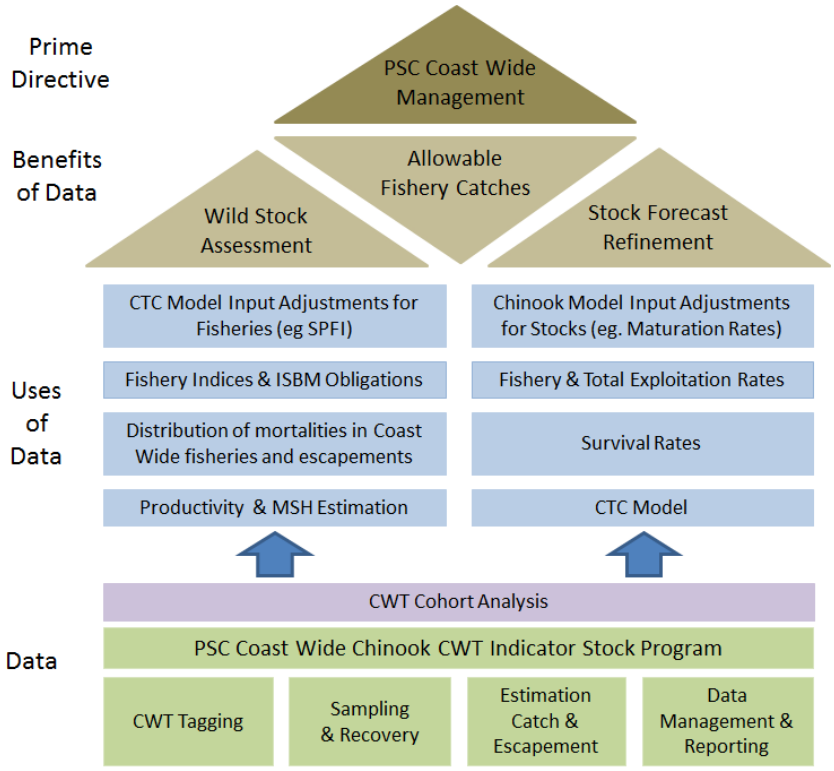


Figure 1.1 Conceptual diagram of the coast wide Chinook CWT Program, including the data generated and uses of the data in the management framework agreed to by Canada and the US in the PST.

2 CWTIP Projects

CWTIP projects and funding distributions by the Parties to address issues identified in PSC TR 25 are summarized in Table 2.1. Projects to improve CWT tagging and sampling accounted for 91% of Canadian CWTIP funding and 72% of US CWTIP funding.

Canada and the US have each invested close to $7.5 M over 5 years on individual projects. CWTIP Projects are summarized in two main categories: 1) improvements in CWT tagging, sampling, and harvest and escapement estimation (which address stock and fishery-specific issues as identified in TR 25 (PSC 2008) Figure 4-2 and 2) improvements in the respective agency /tag labs data coordination and reporting, as identified in TR 25 but not captured in TR 25 Figure 4-2. Some individual projects address multiple issues, so the allocation of funding by issue is approximate.

The majority of the Canadian investment has occurred on multi-year projects under category 1. Improvement projects under data coordination and reporting have generally been one time investments. The US has invested the majority of funding on category 1, but a substantial investment has been made on improvements in category 2 including major upgrades to the CWT reporting systems in Oregon and Washington, and minor upgrades in Alaska.

Canada evaluated its existing indicator stocks for effective tag release levels and determined that because of decreasing exploitation and survival rates, release levels for all facilities should be increased to meet recovery standards developed by the Chinook CWT Workgroup in TR 25 (PSC 2008). These increases varied among indicator stocks because of differential survival and exploitation rates.

In addition to funding provided by the Parties, Northwest Marine Technology, Inc. has worked with agencies to defray costs of increasing tagging levels, and to reduce costs and improve detection efficiency of electronic CWT detectors.

At times it can be difficult to separate CWTIP funded projects from programs conducted by agencies using other funding. For example, in Canada some CWTIP projects were developed to estimate costs and quality of information that would result from the redesign of CWT sampling programs. In the US, CWTIP projects have included funding provided for CWT sampling of Washington and Oregon marine fisheries to address the loss of funding from Anadromous Fish Act grants. Operational projects have also included projects to evaluate the feasibility of methods to reduce costs or improve the timelines of providing CWT data.

Funding for CWTIP for US and Canadian projects is summarized by year in Tables 2.2 and 2.3, respectively, and related to the issues identified in TR 25. The objective of all of these measures is to reduce uncertainties about CWT-derived statistics.

Table 2.1 Total investment (2009-2014) in the CWTIP by Party and by issue identified in PSC TR 25.

Issue #	Technical Report 25 Issue	Canada		US	
		Total Funding	% Funding	Total Funding	% Funding
CWT Tagging and Sampling					
1	Representation of Production Regions	$732,761	9.9%	$1,352,580	18.0%
2	Determination of Tagging Levels	$2,214,074	29.8%	$198,162	2.6%
3	Representation of Hatchery Production	$5,500	0.1%	$141,462	1.9%
4	Low Sampling Rates in Terminal Fisheries	$698,500	9.4%	$425,814	5.7%
5	Low Sample Rates in Escapements	$403,765	5.4%	$5,628	0.1%
6	Uncertainty in Estimates of Escapement or Catch	$425,295	5.7%	$256,160	3.4%
7	Low Sample Rates in Highly Mixed Stock Fisheries	$449,900	6.1%	$2,234,080	29.8%
8	Uncertainty in Estimates of Catch in Mixed Stock Fisheries	$324,100	4.4%	$14,843	0.2%
9	Non-representative Sampling	$326,215	4.4%	$111,604	1.5%
10	Incomplete Coverage of Fisheries or Escapement	$611,355	8.2%	$126,670	1.7%
11	Voluntary Sport Fishery Sampling Programs	$423,940	5.7%	$0	0.0%
12	Sampling to Facilitate Mark Selective Fishery Evaluations	$101,040	1.4%	$557,794	7.4%
	sub total	**$6,716,445**	90.5%	**$5,424,797**	72.4%
Data Coordination and Reporting					
13	Timeliness of Reporting	$176,000	2.4%	$934,495	12.5%
14	Incomplete/No Exchange of CWT Data	$188,100	2.5%	$384,738	5.1%
15	Inter/Intra Agency Coordination	$166,500	2.2%	$82,775	1.1%
16	Unclear Authority to Enforce/Establish Protocols	$0	0.0%	$0	0.0%
17	Updating CWT Data is Difficult/Cannot Be Tracked	$88,000	1.2%	$168,364	2.2%
18	Validation is Inadequate For Current Uses of CWT Data	$88,000	1.2%	$201,428	2.7%
19	Inadequate Funding	$0	0.0%	$156,250	2.1%
DTT	Funding Guidance	$0	0.0%	$141,586	1.9%
	sub total	**$706,600**	9.5%	**$2,069,636**	27.6%
	2009-2014 Total	**$7,423,045**		**$7,494,433**	

Table 2.2 CWTIP projects funded in the US from 2010 through 2014.

Issue	Project	2010	2011	2012	2013	2014	Total
Fishery Catch and Sampling							**$2,918,800**
7	Sampling Washington Coast Sport & Troll		$353,100	$339,400	$354,492	$252,912	$1,299,904
4,6,9,10	Puget Sound Freshwater Sport Sampling	$182,455	$182,824	$185,122			$550,401
7,13	Sampling Oregon Columbia River Management Area for Sport & Troll Fisheries		$100,136	$100,101	$112,597	$165,289	$478,123
7	SEAK Marine Sport Catch Sampling		$79,725		$57,367	$58,266	$195,358
7	SEAK Tag Lab Support For Increased Heads	$64,980	$69,773				$134,753
4,7	SEAK Net & Terminal Commercial CWT Sampling Rate Increase	$43,408	$69,650				$113,058
7	SEAK Commercial Port Sampling	$42,580			$58,164		$100,744
7,10,13	Makah Tribal Fishery – Ocean Sampling				$46,459		$46,459
Indicator Stocks							**$1,912,630**
1, 3, 4, 5, 6	Elk River CWT--Indicator Stock—Tagging, Terminal Run Estimation and Sampling	$112,565	$140,118	$123,501	$125,195	$131,500	$632,879
1,2	Stikine CWT--Wild Indicator Stock Tagging	$121,264	$113,818	$121,883	$134,562	$134,562	$626,089
1,2	Chilkat CWT--Wild Indicator Stock Tagging	$91,119	$97,715		$86,801	$89,084	$364,719
1,3	Salmon River Indicator Stock—Escapement and Hatchery-Wild Comparison		$144,494			$114,055	$258,549
6,9,10,15,19	Lower Columbia R Escapement Estimation & CWT expansions	$20,112					$20,112
1	CWT of Nisqually River Indicator Stock		$10,282				$10,282
CWT Project Planning							**$41,586**
Analytical	Decision-Theoretic Tool; Financial Decisions	$141,586					$141,586
Information Management							**$1,090,154**
12-15, 17,18	ODFW CWT Database & Reporting System	$410,000		$110,000	$99,653	$74,942	$694,595
12-14, 18,19	WDFW Database & Reporting System	$235,519		$72,206			$307,725
14,18,13	SEAK CWT Database & Reporting System			$29,685	$29,304		$58,989
10,19	SEAK Seine CWT Expansions & Strata Reconfiguration	$28,845					$28,845

Issue	Project	2010	2011	2012	2013	2014	Total
Equipment							**$1,339,682**
12,13	WDFW Hand-held T-wands—Electronic Sampling Fisheries and Escapements			$230,456	$248,543	$187,527	$666,526
12,13	ODFW Hand-held T-wands—Electronic Sampling Fisheries and Escapements			$80,710	$101,063		$181,773
12,14	SEAK Commercial Sampling Data Loggers		$49,590			$95,122	$144,712
4,7,13,19	SEAK Hand-held T-wands—Reduction of Sampling & Processing Costs			$131,309			$131,309
12,13	NWIFC Hand-held T-wands—Electronic Sampling Fisheries and Escapements					$130,708	$130,708
7,12,14	Makah Tag Lab equipment			$5,312		$61,562	$66,874
7,13	Lummi Tribe CWT Lab Equipment				$12,607		$12,607
7,13	Stillaguamish CWT Lab Equipment				$5,173		$5,173
Administration							**$91,581**
	PSC Grant for CWTIT meetings		$21,090		$13,200	$23,000	$57,290
	Administrative: US CWTIT Co-chair				$14,820	$19,471	$34,291
	TOTALS	**$1,494,433**	**$1,432,315**	**$1,529,685**	**$1,500,000**	**$1,538,000**	**$7,494,433**

Table 2.3 CWTIP projects funded in Canada from 2009 through 2013.

Issue	Project	2009	2010	2011	2012	2013	Total
Fishery Catch and Sampling							**$1,687,300**
2, 4, 5, 7,10,11	CWT Head Lab Processing and Data Management	$44,400	$80,000	$95,000	$70,000	$194,000	$483,400
4,7,9,10,11	Regional Sport & FN Fishery CWT Recovery Coordination	$71,400	$85,000	$85,000	$85,000	$85,000	$411,400
6,7,8,9,10	Expansion Catch Monitoring & Sampling Southern BC Sport Fishery		$80,000	$180,000	$100,000		$360,000
4,10	Lower Fraser First Nations CWT Recovery		$15,000	$40,000	$25,000	$25,000	$105,000
11	Recreational Fishery CWT Sampling			$39,000	$30,000	$25,000	$94,000
4,6	Lower Fraser First Nations Fishery CWT Sampling			$35,000	$25,000	$25,000	$85,000
4,10	Middle Shuswap Sport Fishery Catch Estimation and CWT Sampling			$20,000	$12,000		$32,000
4,6	Expansion Catch Monitoring & Sampling Chilliwack River Sport Fishery			$15,000	$15,000		$30,000
4,10	Georgia Strait First Nation Fishery CWT Recovery Improvements			$14,000	$14,000		$28,000
4,10	WCVI FN Fishery CWT Recovery Improvements		$10,000	$6,000	$6,000		$22,000
10	Central Coast Sport Creel & Sampling			$5,000	$7,000	$10,000	$22,000
7, 9,10	Middle Shuswap Sport Fishery Catch Card Pilot			$9,500			$9,500
7,9	Northern Troll Fishery Sampling			$5,000			$5,000
Indicator Stocks							**$3,485,745**
2	Purchase CWT s for Incremental Tagging	$493,478	$211,167				$704,645
1, 5, 6	Atnarko Chinook CWT Indicator Stock	$120,000	$84,500	$109,500	$110,000	$110,000	$534,000
2	Increased CWT Tagging Cowichan Chinook Indicator	$86,000	$39,000	$55,000	$63,000	$63,000	$306,000
2	Increased CWT Tagging Robertson Creek Chinook Indicator	$60,500	$32,000	$33,000	$35,000	$35,000	$195,500
2	Increased CWT Tagging Quinsam Chinook Indicator		$39,000	$40,000	$43,500	$43,500	$166,000

Issue	Project	2009	2010	2011	2012	2013	Total
2	Increased CWT Tagging Taku Chinook Indicator	$30,000	$30,000	$30,000	$30,000	$30,000	$150,000
2	Increased CWT Tagging Stikine Chinook Indicator	$30,000	$30,000	$30,000	$30,000	$30,000	$150,000
5	Increased CWT Recovery Effort Cowichan Indicator Escapement	$30,000	$25,000	$30,000	$30,000	$30,000	$145,000
2	Increased CWT Tagging Lower Shuswap Chinook Indicator		$39,000	$33,000	$34,500	$33,000	$139,500
2	Increased CWT Tagging Harrison Chinook Indicator	$39,000	$15,000	$20,000	$28,600	$28,600	$131,200
2	Increased CWT Tagging Big Qualicum Chinook Indicator		$27,000	$26,000	$29,000	$25,000	$107,000
2	Increased CWT Tagging Kitsumkalum Chinook Indicator	$25,000		$25,000	$25,000	$25,000	$100,000
5	Increased CWT Recovery Effort Harrison Indicator Escapement	$16,000	$16,000	$16,000	$16,000	$16,000	$80,000
2	Alternate Release Strategy Harrison Indicator		$80,000				$80,000
5	Increased CWT Recovery Effort Chilliwack Indicator Escapement	$14,000	$14,000	$14,000	$14,000		$56,000
4,10	Bella Coola River First Nation Fishery CWT Sampling	$10,000	$10,000	$10,000	$10,000	$10,000	$50,000
2	Increased CWT Tagging Philips Chinook Indicator			$28,000	$10,000	$10,000	$48,000
2	Increased CWT Tagging Chilliwack Chinook Indicator		$13,000	$9,000	$12,200	$8,000	$42,200
2	Increased CWT Tagging Nicola Chinook Indicator		$8,000	$11,000	$11,500	$11,500	$42,000
2	Increased CWT Tagging Atnarko Chinook Indicator		$25,000	$5,000	$6,200	$5,000	$41,200
1,6	Data Recovery Historic Fraser River Chinook CWT Data		$20,000	$19,000			$39,000
5	Increased CWT Recovery Effort Quinsam Indicator Escapement	$7,500	$7,500	$7,500	$7,500	$7,500	$37,500
5	Increased CWT Recovery Effort Nicola Indicator Escapement	$4,000	$4,000	$8,000	$8,000	$8,000	$32,000
4,6	Atnarko River Sport Fishery CWT Sampling &	$5,000	$5,000		$10,000		$20,000

Issue	Project	2009	2010	2011	2012	2013	Total
	Creel Survey						
6	Coded -Wire-Tagging Training Workshop	$20,000					$20,000
5	Increased CWT Recovery Effort Big Qualicum Indicator Escapement			$5,000	$5,000	$3,000	$13,000
1, 6,13	QA/QC Fraser River Chinook Indicator Stock AFC/CWT Data			$12,000			$12,000
3	Increased CWT Tagging Middle Shuswap Chinook Indicator	$11,000					$11,000
5	Increased CWT Recovery Effort Kitsumkalum Indicator Escapement		$10,000				$10,000
2	Evaluation CWT Placement study		$10,000				$10,000
14	Recovery Juvenile CWT Data From Research Surveys			$5,000			$5,000
5	Increased CWT Recovery Effort Robertson Creek Indicator Escapement	$2,000	$2,000				$4,000
4,10	Cowichan River First Nation Fishery CWT Sampling	$2,000	$2,000				$4,000
Information Management							**$1,909,100**
13, 14,17,18	Regional CWT Data System Programming	$80,000	$90,000	$90,000	$90,000	$90,000	$440,000
6,8	Regional CWT and Catch Estimation QA/QC	$39,700	$75,000	$75,000	$75,000	$75,000	$339,700
10	Salmonid Enhancement Database Improvements				$67,000	$75,000	$142,000
8,13	Commercial Catch Database (FOS) Improvements				$60,000		$60,000
13	Computer Programming & Sampling Protocols: label barcodes		$50,000				$50,000
10	Chinook Test Fishery CWT and Biosample Data Capture			$26,000	$15,000		$41,000
14	Mark Recovery Program Archive Data Recovery				$20,000	$20,000	$40,000
9	Web-Based GIS Mapping Sport Locations		$40,000				$40,000
8,15	Recreational Catch Database (KREST) Improvements			$30,000			$30,000
8,12	Feasibility & Design Regulations Database		$20,000	$9,500			$29,500

Issue	Project	2009	2010	2011	2012	2013	Total
4,7,9,10,11,12	Regional Commercial, Sport & FN Fishery CWT Recovery Improvements	$71,500	$74,000	$123,000	$174,000	$254,400	$696,900
Equipment							**$340,900**
2,4,5,7,10,11	Purchase Lab Equipment	$12,000	$15,000			$6,000	$33,000
4,7,9,10,11	Purchase CWT Wand Detectors for Commercial Fishery Sampling				$39,000	$55,000	$94,000
4,7,9,10,11	Purchase CWT Tube Detectors and Custom Infrastructure for Commercial Fishery Sampling	$10,000	$54,000	$15,000		$15,000	$94,000
4,7,9,10,11	Purchase Freezers and Custom Infrastructure for Recreational Fishery Sampling	$8,500	$12,000	$2,000	$2,000	$13,500	$38,000
2	Purchase Tagging Equipment for Big Qualicum, Quinsam and Chilliwack Hatcheries	$81,900					$81,900
	TOTALS	**$1,424,878**	**$1,498,167**	**$1,500,000**	**$1,500,000**	**$1,500,000**	**$7,423,045**

3 Changes to TR 25 Assessment of Chinook CWT Program

Improvements for the assessment of stocks and fisheries that were identified in TR 25 (PSC 2008) have occurred since the start of the CWTIP funding. TR 25 identified and summarized gaps and deficiencies for individual stocks and fisheries in the PST area, as well as those that met or exceeded statistical criteria of the PSC CWT Work Group for analysis that PSC technical committees use to evaluate the management regimes. Note that this section does not include CWTIP funding that addressed issues related to Data Coordination and Reporting (lower half of Table 2.1), nor does it cover new CWT indicator stocks that have been incorporated by the CTC since publication of TR 25.

Figures 3.1 and 3.2 provide a visual basis to compare the change in status of specific stocks and fisheries that received CWTIP funding. Figure 3.1 is an extraction of Figure 4-2 in TR 25 and portrays the status of tagging and sampling levels and associated CWT data in fisheries and escapements during 2000-2004 using statistical criteria set by the PSC CWT Workgroup. Green cells indicate that a stock or fishery met or exceeded all criteria, e.g., tagging of indicator stocks, enumeration and associated precision of fisheries and escapement and sampling levels of fisheries and escapements. Yellow cells indicate that a stock or fishery failed to meet 1 of 3 criteria. Red cells mean that 2 or more criteria were not met and are the most problematic for data analysis. Blank cells are not applicable to the specific stock or fishery. Figure 3.2 represents the CWTIT's qualitative evaluation of the color (status) of each cell after 5 years of CWTIP funding. An empirical assessment utilizing statistical criteria similar to that employed in the formation of the TR 25 Red/Yellow/Green figure would be an appropriate analysis in preparation for upcoming PST Chapter renegotiations.

The CWT system for Chinook salmon has been substantially improved for stock and fishery analysis over the 5-year CWTIP. Of the 244 colored cells in Figure 3.1 (prior to the CWTIP), 27% were red, while in Figure 3.2, as a result of CWTIP funding, the proportion of red cells have decreased to 1% (Figure 3.3). Also, 65 stock or fishery cells (33% of the former red and yellow cells, including 97% of the red cells) have improved status for estimating statistics for management (either from red to yellow or from yellow to green).

It should be noted that during the period of the CWTIP, support for baseline monitoring and sampling programs continued to deteriorate and these programs were only maintained through the use of CWTIP funds. **Without continuation of annual funding, the status of the CWT system for Chinook salmon would quickly deteriorate to a state worse than that described in TR 25.**

STOCK INFORMATION									REGIONAL MIXED-STOCK FISHERIES																				
		Stock Specific Key Issues							Fishery Specific Key Issues																				
Region	Stock	Release	Escapement (Hatchery)	Escapement (Sp Grounds)	Term Com	Term Native	Term Spt		SEAK Troll	SEAK SPT	SEAK Net	NCBC Troll	NCBC Sport	NCBC Net	WCVI Troll	WCVI Sport	Geo Strait Troll	Geo Strait Spt	SBC Net	WAOcn Troll	WA Ocn Sport	PS Sport	WA Net	Col Riv Sport	Col Riv Net	OR Coast Troll	OR Coastal Sport	
Alaska	Alaska Central Inside	1	1	1					1	2																			
	Little Port Walter	1	1	1					1																				
	Alaska Southern Inside	1	1	1	1				1	2																			
Canada	Big Qualicum	1	1		3	3	3		2				3					3											
	Chilliwack (Harrison Fall Stock)	2		2		3									1	3		2		1									
	Cowichan	1	1			3	3								2	3							2						
	Kitsumkalum	1				3	3		1				3																
	Puntledge	2	1		3	3	3		2				3					3											
	Quinsam	1	1	1	3	3	3		1				3																
	Robertson Creek	2	1	1	1	2	3		1				3			3													
	Atnarko / Snootli	3			3	3	3		2			2	3	2															
Washington	George Adams Fall Fingerling	1	1	3	2		3								1	3				1		1	2						
	Green River Fall Fingerling	1	1	2	1										1	3		3		2		1	1						
	Grovers Creek Fall Fingerling	1	1												1	3				1		1	1						
	Hoko Fall Fingerling	3	1	2					1			2																	
	Nisqually Fall Fingerling	1	1		1		3								1							1							
	Nooksack Spring Fingerling	2	1	2					2						1	3		3											
	Queets Fall Fingerling	2		3	1				1			1	3																
	Samish Fall Fingerling	1	1				3								1	3		3		2		2	1						
	Skagit Spring Fingerling	1	1												1	3						2							
	Skagit Spring Yearling	2	1												1	3						1							
	Sooes Fall Fingerling	2	1		2				2			2	3																
	South Puget Sound Fall Yearling	1	2		2											3						2	2						
	Skagit Summer Fingerling	3							1				3		2	3		3											
	Stillaguamish Fall Fingerling	3	1	2											2	3		3				2							
	White River Spring Yearling	3	1																			2							
Oregon	Salmon River	2		1			2		1			1																	
Columbia River	Cowlitz Tule	1	1	3					2						2	3				2	2				2	2			
	Hanford Wild	1		2					1			2													1				
	Columbia Lower River Hatchery	1	1												1	3				1	2				1	1			
	Lewis River Wild	3							2			2			2	3				2					2	2			
	Lyons Ferry	3													2					1	1				1	2			
	Spring Creek Tule	1	1												1	3				1	1				1	1			
	Columbia Summers	1	1						1			1	3		1	3				1						1			
	Upriver Bright	1	1						1			2													1				
	Willamette Spring	1	1				2		1																1				

1 indicates that all criteria were met; 2 indicates that one criteria is not met; 3 indicates that two or more criteria are not met

Figure 3.1 Figure 4-2 extracted from TR 25 identifying stock and fishery-specific issues.
[Figure 4-2. Results of evaluating tagging, fishery and escapement sampling levels using criteria set by workgroup for Chinook salmon. A blank cell indicates a fishery did not represent over 2.5% of the total exploitation for a stock. Green (1), yellow (2), or red (3) cells represent different situations with respect to the criteria as noted below; corresponding numbers are useful for black and white reproduction].

STOCK INFORMATION									REGIONAL MIXED-STOCK FISHERIES																				
		Stock Specific Key Issues							Fishery Specific Key Issues																				
Region	Stock	Release	Escapement (Hatchery)	Escapement (Sp Grounds)	Term Com	Term Native	Term Spt		SEAK Troll	SEAK SPT	SEAK Net	NCBC Troll	NCBC Sport	NCBC Net	WCVI Troll	WCVI Sport	Geo Strait Troll	Geo Strait Spt	SBC Net	WAOcn Troll	WA Ocn Sport	PS Sport	WA Net	Col Riv Sport	Col Riv Net	OR Coast Troll	OR Coastal Sport	
Alaska	Alaska Central Inside	1	1	1					1	1																			
	Little Port Walter	1	1	1					1																				
	Alaska Southern Inside	1	1	1	1				1	1																			
Canada	Big Qualicum	1	1		2	2	2		1				2					2											
	Chilliwack (Harrison Fall Stock)	1		1		2									1	2		1		1									
	Cowichan	1	1			2	2								2	2							2						
	Kitsumkalum	1				2	3		1				2	2															
	Puntledge	1	1		2	2	2		1				2					2											
	Quinsam	1	1	1	2	2	2		1				2																
	Robertson Creek	1	1	1	1	1	2		1				2			2													
	Atnarko / Snootli	1			1	1	1		1			2	2	2															
Washington	George Adams Fall Fingerling	1	1	2	2		2								1	2				1		1	2						
	Green River Fall Fingerling	1	1	2	1										1	2		2		1		1	1						
	Grovers Creek Fall Fingerling	1	1												1	2				1		1	1						
	Hoko Fall Fingerling	1	1	2					1			2																	
	Nisqually Fall Fingerling	1	1		1		2								1							1							
	Nooksack Spring Fingerling	1	1	1					2						1	2		2											
	Queets Fall Fingerling	1		2	1				1			1	2																
	Samish Fall Fingerling	1	1				3								1	2		2		1		2	1						
	Skagit Spring Fingerling	1	1												1	2						2							
	Skagit Spring Yearling	1	1												1	2						1							
	Sooes Fall Fingerling	1	1		2				2			2	2																
	South Puget Sound Fall Yearling	1	2		2											2						2	2						
	Skagit Summer Fingerling	1							1				2		2	2		2											
	Stillaguamish Fall Fingerling	1	1	2											2	2		2				2							
	White River Spring Yearling	1	1																			2							
Oregon	Salmon River	1		1			1		1			1																	
Columbia River	Cowlitz Tule	1	1	1					2						2	2				1	1				1	1			
	Hanford Wild	1		1					1			2													1				
	Columbia Lower River Hatchery	1	1												1	2				1	1				1	1			
	Lewis River Wild	1							2			2			2	2				1					1	1			
	Lyons Ferry	1													2					1	1				1	1			
	Spring Creek Tule	1	1												1	2				1	1				1	1			
	Columbia Summers	1	1						1			1	2		1	2				1						1			
	Upriver Bright	1	1						1			2													1				
	Willamette Spring	1	1				2		1																1				

1 indicates that all criteria were met; 2 indicates that one criteria is not met; 3 indicates that two or more criteria are not met

Figure 3.2 A qualitative assessment by the CWTIT of the color (status) of stock- or fishery-specific cells where CWT improvements were realized over the 5-year CWTIP, to provide a comparison to Figure 3.1 above. Cells to the left of the vertical black line are stock issues and those to the right are mixed stock fishery issues.

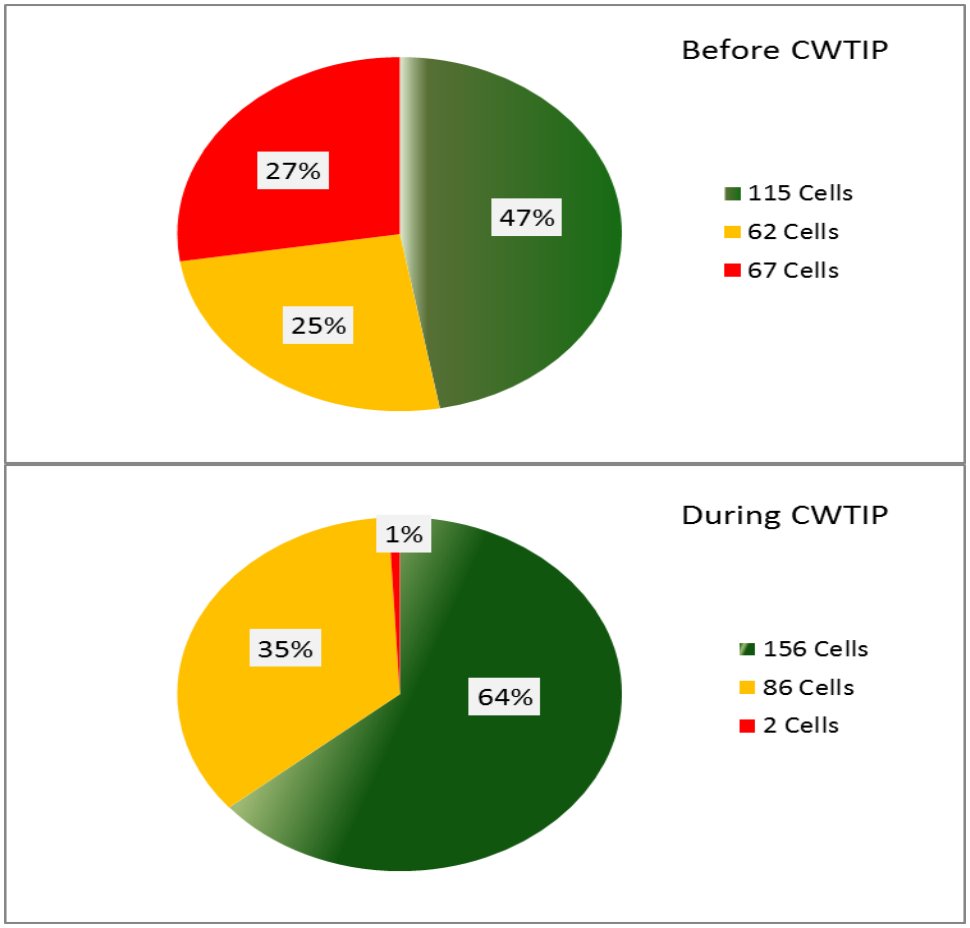


Figure 3.3 The estimated percentage and number of the 244 total colored cells representing stock- and fishery-specific status (green, yellow or red) before CWTIP funding in Figure 3.1 (upper chart) and during CWTIP funding in Figure 3.2 (lower chart).

4 Improvements Resulting From CWTIP Projects

CWTIP-funded improvements are categorized on a time-scale basis as: (1) "short & intermediate term" and (2) "legacy".

"Short term - intermediate" projects are those that provide temporary benefits, maintain existing capabilities, and/ or require annual investment to maintain.

Examples of short and intermediate term projects include:

a. Indicator stock tagging and sampling programs to fill information gaps. Examples of such projects include increased representation of production regions by indicator systems and increased tagging of existing indicators. CWTs from augmented CWT releases began being encountered in two-year-old Chinook in fishery and escapement sampling programs in 2011 but all possible marine ages will not be represented until at least 2015.

b. Increased coverage and sampling of terminal, sport and select commercial fisheries resulting in increased accuracy and precision of exploitation rate estimates for CWT indicator stocks, and

c. Increased effort in monitoring and sampling escapements of indicator stocks, which result in increased accuracy and precision of indicator cohort abundance, survival rates, and exploitation rates.

The full realization of the improvements resulting from these types of CWT projects and ability to sustain these improvements in the future will depend on the availability of funding beyond the CWTIP.

"Legacy" projects are those that will provide lasting improvements to the CWT system, including improvements to database and reporting activities, reduced costs, improved efficiency of CWT data collection and improved accuracy of CWT data and statistics.

Examples of legacy projects include:

a. Improvements to the coordination of agency CWT programs including collection, transfer and management of CWT heads and data reporting procedures,

b. Improvements to intra and inter-agency data exchange protocols,

c. Validation and corrections to data and historical CWT estimation algorithms,

d. Updating and integration of agency computer programs to improve the consistency, timeliness, and accuracy of CWT data retrieval and data reporting,

e. Development of a Decision-Theoretic Tool for planning individual or multiple CWT improvement programs (tagging, sampling, catch/escapement estimation), and

f. Purchase of new or replacement equipment for sampling and processing CWTs, such as electronic CWT detectors and microscopes.

4.1 Short & Intermediate Term

Highlighted stocks and fisheries in Figures 3.1 and 3.2, as well as Tables 2.1-2.3, indicate where CWTIP funding was directed for short and intermediate term improvements (CWT tagging and sampling for stocks and fisheries). CWTIP projects addressed stock and/or fishery-specific issues of inadequate CWT tagging, catch monitoring, and sampling rates identified in TR 25. Benefits from these types of projects are considered short term and require annual investment to maintain, but leave intermediate benefits as the projects provide improved data for the years implemented and provide inferences for the past and future, even if discontinued.

4.1.1 Indicator Stock Programs

The columns to the left of the heavy vertical lines in Figures 3.1 and 3.2 relate to CWT indicator stocks. Issues relating to indicator stocks as reported in TR 25 and those resulting from CWTIP projects are graphically compared in Figure 4.1. The status of indicator stock has improved from 28% red cells prior to CWTIP funding to 2% red cells as a result of 5-years of CWTIP funding.

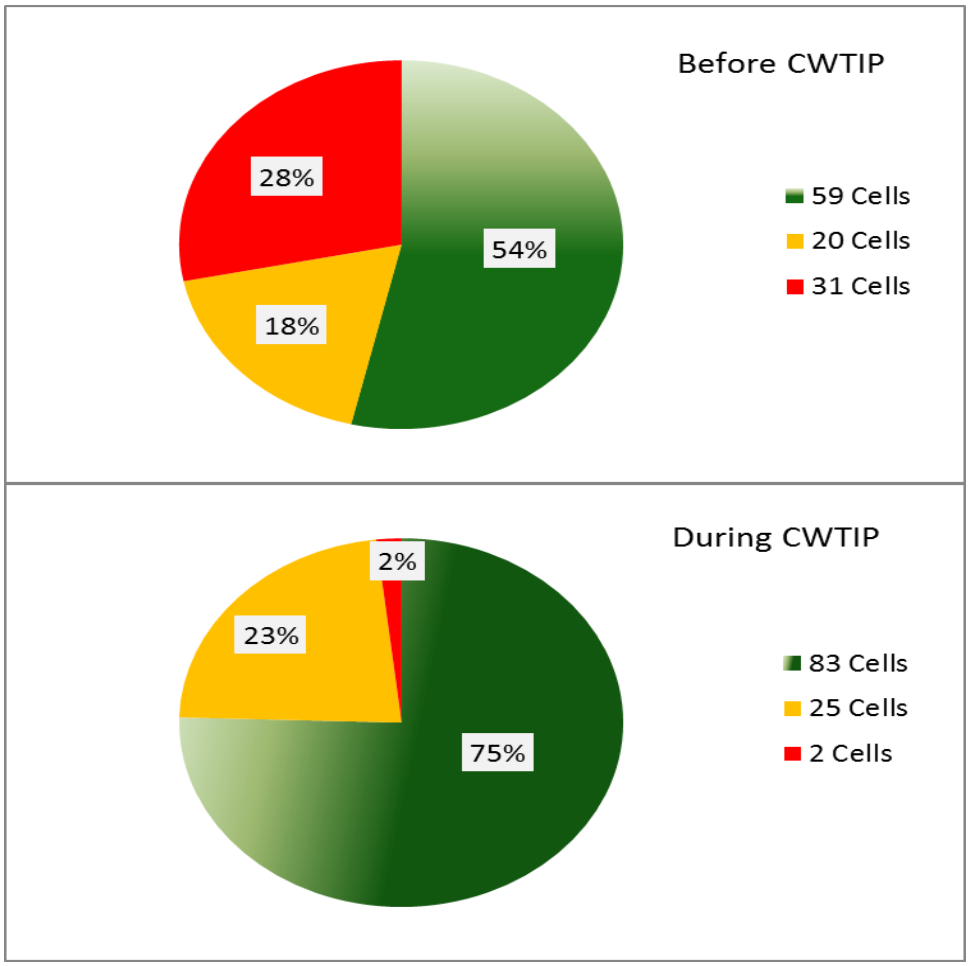


Figure 4.1 The estimated percentage and number of the 110 total colored cells representing indicator stock status (green, yellow or red) before CWTIP funding in Figure 3.1 (upper chart) and during CWTIP funding in Figure 3.2 (lower chart).

CWT indicator stock programs are used for PST and domestic management. These programs provide stock-specific estimates of exploitation, harvest distribution, survival, maturation rates and total production, from CWT recovery data in fisheries and escapements. Each CWT indicator stock must have the following components to useful for analysis:

1) A representative and adequate CWT release group (fry or smolt);
2) Estimates of total escapement that are unbiased;
3) CWT sampling in escapements that produces unbiased estimates of the numbers of CWTs in the escapement;
4) Estimates of catch in all fisheries that harvest this stock; and
5) Direct CWT sampling in all terminal and ocean fisheries that produces unbiased estimates of CWTs in each fishery; or indirect methods that produce these same statistics.

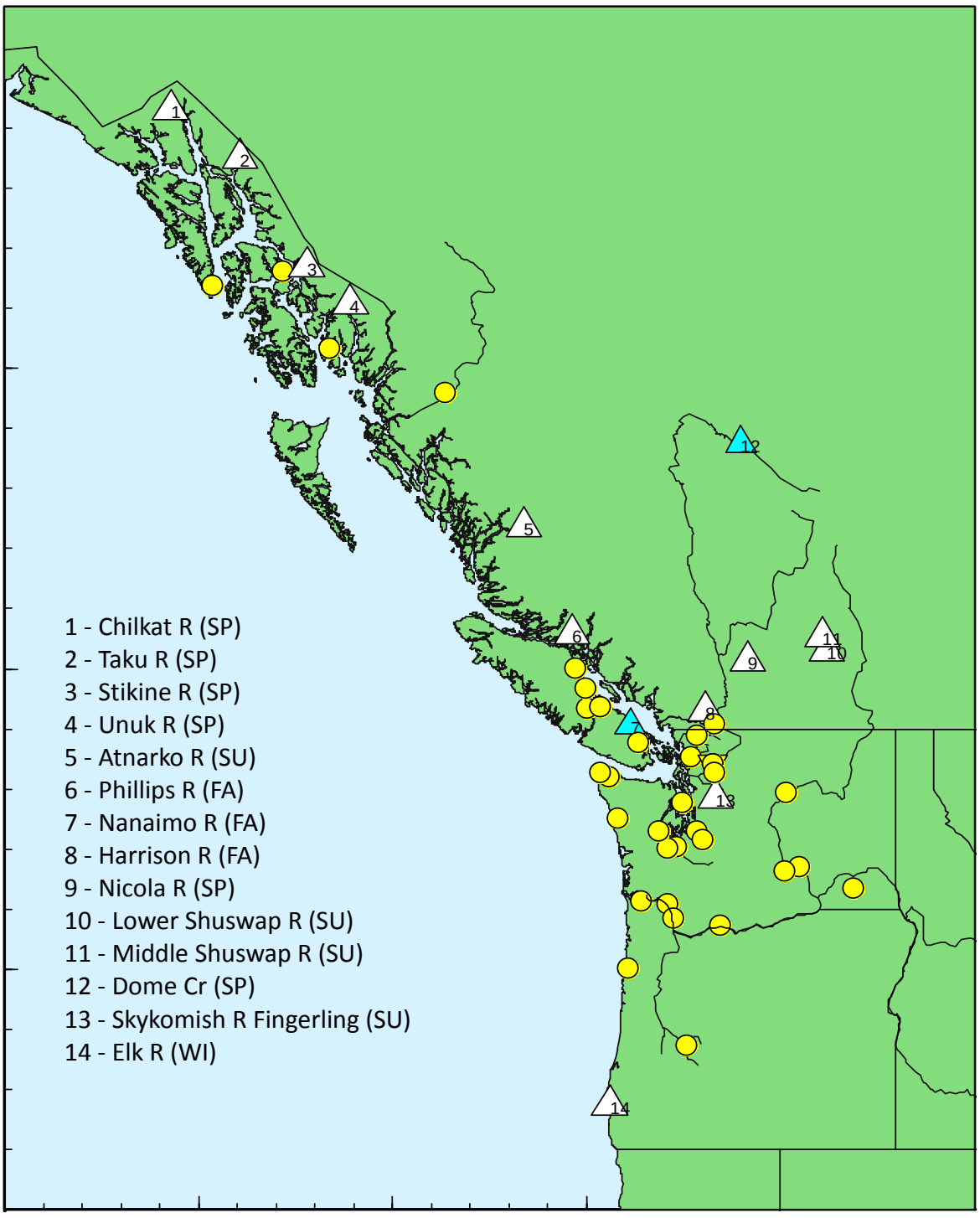


Figure 4.2 Geographical distribution of coast wide Chinook salmon CWT indicator stocks. Yellow circles indicate CWT indicators existing prior to TR 25. Numbered triangles indicate CWT indicators developed since the completion of TR 25. Their names are given in the legend followed by adult run timing in brackets (SP = spring, SU = summer, FA = fall and WI = winter). Blue triangles indicate the location of discontinued indicators.

The CTC uses data from CWT indicator stocks to conduct stock-specific cohort analysis used in the annual exploitation rate procedure. As a result of the CWTIP, data for 11 additional indicator stocks are available for inclusion in the cohort analyses. The results are published annually in the CTC's report on the exploitation rate analysis and Chinook Model calibration for the current fishing season.

Since the completion of TR 25, a total of 14 additional CWT indicator stocks have been developed and these occur throughout the geographic range under jurisdiction of the PST (Figure 4.2). These additional indicators extend the geographic coverage both northward and southward (Figure 4.2, see Chilkat River - 1 in Southeast Alaska (SEAK) and Elk River – 14 in Oregon). Four have been added in SEAK, all based on wild smolt tagging programs. Eight have been added in British Columbia (BC). One occurs along east coast Vancouver Island. Two indicators, the Atnarko River and the Phillips River, occur along coastal mainland BC where previously none existed between the Fraser River in the south and the Skeena River in the north. Five others are within the Fraser River drainage and these fill gaps in geographic coverage and life history variation. Two of the eight recently developed BC indicators have been discontinued due to funding shortfalls. In the southern US, one indicator has been added in Puget Sound and one in coastal Oregon.

As part of the expanded CWT application projects in BC, Northwest Marine Technologies provided 4 million free tags over 4 years in-kind to DFO to support the expanded tagging program. This partnership recognized the importance of maintaining tagging rates as a crucial component for a functioning CWT program, and has helped to ensure the viability of this program for years to come.

CWTIP funding was used to improve CWT indicator stocks in BC and the US (Table 4.1). In BC, additional tagging was funded for 10 long-term indicator stocks (Table 2.3), after determination that the former standard CWT release size of 200,000 for fall Chinook was generally too low due to reductions in survival, sampling and exploitation rates. Canadian funding was also provided to capture and tagging of wild smolt from the transboundary Taku and Stikine River stocks. Funding was also provided to improve estimates of escapements and CWT sampling for the indicator stocks. In the US, funding was provided for capture and tagging of wild Chinook on the Stikine and Chilkat rivers, and for tagging, estimating terminal run size and escapement sampling for the Elk River stock on the mid-Oregon coast. Funding was provided to increase or implement sampling of terminal tribal/native, sport and commercial fisheries necessary to provide CWT data needed to assess indicator stocks.

Table 4.1 Improvements in indicator stock programs resulting from CWTIP funding.

Key Issues		
Tagged Releases	Canada	Increased CWT application at 10 Canadian Chinook exploitation rate indicator stocks from 2.5 M in 2007 to average 4.7 M tags during 5 year funding period, meeting all tag application standards for desired precision in estimates (TR 25, table 5.1). CWTs from augmented releases have been encountered in fisheries and escapement sampling program since 2011 and will continue to be encountered until 2018.

Key Issues		
	US Alaska Oregon	Wild CWT indicators were developed and implemented on several SEAK rivers, including the Stikine, Taku, Unuk, and Chilkat rivers. Development of several transboundary and SEAK wild indicators allows for more precise estimates of exploitation rate and survival in northern and transboundary fisheries. Extended the geographic coverage of releases to include the mid-Oregon Coastal production area.
Escapement (Hatchery)	Canada & US	Sampling rates in BC and US hatcheries were adequate prior to the 5 year funding period. With increased CWT application in BC, the number of tagged fish recruiting to escapement has increased and target sampling rates have been maintained.
Escapement (Spawning Grounds)	Canada	With increased CWT application, sample rates were maintained or increased at 7 indicators, including a new Central Coast BC (CBC) indicator at Atnarko River (Snootli Hatchery).
	US Oregon	Escapement sampling rate has been maintained above 12% since the CWTIP has supported tagging and recovery efforts in the Elk River from 2010 through 2012. Total terminal escapement sampling rates (sport, hatchery and spawning ground) have increased from 34% in 2010 to 38% in 2011 to 61% in 2012.
Terminal Commercial	Canada	With increased CWT application, terminal commercial fishery sample rates were maintained or increased at all indicators, including a new CBC indicator at Atnarko River (Snootli Hatchery). The CBC terminal fishery had not been sampled since 2004. CWTIP funds supported sampling at 40% to meet CWT standard target of 20 observed tags for all ages combined.
	US Alaska	Maintained or increased sample rates of over 30% in SEAK drift gillnet, troll and purse seine fisheries. CWTIP funds used to purchase new electronic detection wands, which reduced the incidence of “No Pin” heads processed and sent to dissection lab. This resulted in direct savings in shipping, processing and handling costs.
Terminal Native	Canada	Terminal Native economic opportunity fishery sampling targets were met for Robertson Cr. Terminal Native food, social and ceremonial fisheries sampling targets were met for Atnarko River and Robertson Creek and sampling improvements were made for Big Qualicum River, Cowichan River, Lower Shuswap River and Harrison River indicator stocks.

Key Issues		
Terminal Sport	Canada	CWT estimates for terminal sport fisheries were historically calculated using average sample rates from coast-wide ocean fisheries. Data recovery projects have resulted in improvements calculating CWT estimates using data from terminal sport fishery sampling and creel survey data.
	US Washington	Achieved sample rates of 9-30% on 4 major Puget Sound freshwater fisheries (Nisqually, Skagit, Skykomish, Skokomish). Conducted study to develop and provide guidance on the use of indirect methods for estimating the numbers harvested coded wire tagged Chinook in freshwater fisheries and/or reduced cost methods of direct sampling for CWTs in freshwater fisheries. This is a legacy project.
	Oregon	Sample rates of 34-40% in Elk River terminal sport areas were achieved over the duration of CWTIP support.

4.1.1.1 Examples

4.1.1.1.1 Improved Precision Estimates for Canadian Indicator Stocks

A number of Canadian CWTIP projects focused on increasing the number of CWTs recovered in fishery and escapement samples. This objective was achieved using the following approaches:

- Increasing CWTs applied to indicator stocks;
- Increasing sample rates in fisheries;
- Increasing temporal coverage of fishery sampling; and
- Increasing sampling rates in terminal escapement.

While all of these approaches would be expected to increase the number of recovered CWTs, increasing the number of CWTs applied and released per brood for CWT indicators increases the probability that more CWTs will be recovered. The CWTIP funded an increase in CWT application for 10 Canadian indicator stocks starting with the 2009 brood year (Figure 4.3). Over the five years of CWTIP-funded tagging, nearly 10 million additional CWTs were applied, with a mean stock-specific annual increase of 141% over base agency levels. For those age classes within cohorts that have been recovered in fishery samples there have already been quantifiable benefits.

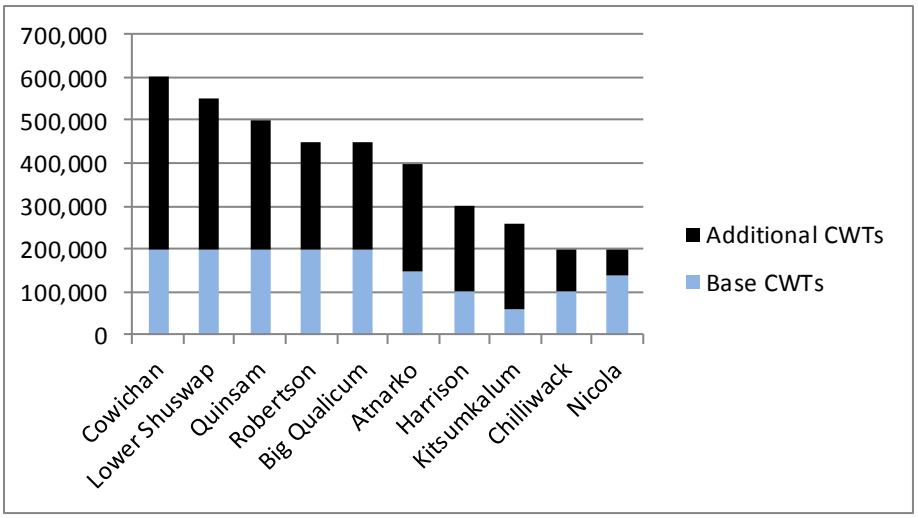


Figure 4.3 CWT targets for Canadian CWT indicator stocks for the 2009-2013 brood years. The height of each bar indicates the target CWT application for each indicator. The lower light portion of the bar indicates the 'base' level of CWTs applied prior to CWTIP funding while the upper dark portion indicates the incremental CWTs applied with CWTIP funding.

Three CWT indicators were selected for evaluation of improvements achieved in numbers of recovered CWTs due to the release of increased numbers of CWTs as well as other initiatives under CWTIP. These indicators were the Cowichan River fall run (east coast Vancouver Island in lower Georgia Strait), the Lower Shuswap River summer run (upper Fraser River) and the Robertson Creek fall run (Somass River at the head of Alberni Inlet, west coast Vancouver Island (WCVI)). Each of these indicators originates from a different geographic region in BC and each has a different oceanic distribution and suite of intercepting fisheries. While substantial fishery impacts occur in Alaskan fisheries for the Robertson Creek stock and in Alaskan and southern US fisheries for the lower Shuswap River stock, the majority of impacts occur in BC fisheries for the Cowichan River stock. Greatest improvement in recovered CWTs was expected for the Cowichan River stock since all the Canadian CWTIP projects aimed at improving CWT recoveries would apply to the potential CWTs available to be recaptured in fisheries and the escapement.

Four metrics were identified to demonstrate improvements to desirable aspects of CWT data. These were:

1) Relative percentage increase in total observed CWTs recovered in fishery samples;
2) Relative percentage increase in fishery-age combinations with one or more recoveries;
3) Relative percentage increase in fishery-age combinations with >10 observed CWTs; and
4) Relative percentage increase in fishery-age combinations with >30 estimated CWTs.

Relative percentage increases were calculated for each metric as the ratio of the difference between the total CWTs from three broods (2008-2010) and the CWTs from a set of tag codes from the same broods arbitrarily chosen to approximate the base tagging level ("the base codes"), divided by the base codes, then multiplied by 100% to convert to a percentage. An alternate approach to showing improvements in the CWT data based on comparing recoveries from broods completed during the CWTIP funding to those completed prior to CWTIP funding was also considered. Since broods (and thus the number of recoveries) in the two time periods

would be influenced by differences in mortality rates, sampling rates, fishery magnitudes, and gear variations or regulations, the expected improvements to CWT data could be obscured. The approach that was chosen, while not ideal due to the arbitrary selection of the 'base' tag codes, avoided the complications of the other approach.

Substantial improvement was observed in all metrics for each of the three indicator stocks (Figure 4.4). Variation in the magnitude of increase occurred among the indicators and among the metrics but the relative percentage increases in all metrics was greatest for the Cowichan River stock. This is likely because the majority of Cowichan fish are impacted by fisheries in BC (and thus subject to all possible improvements in fishery sampling coverage and rates) and also because the increase in tagged fish was the greatest.

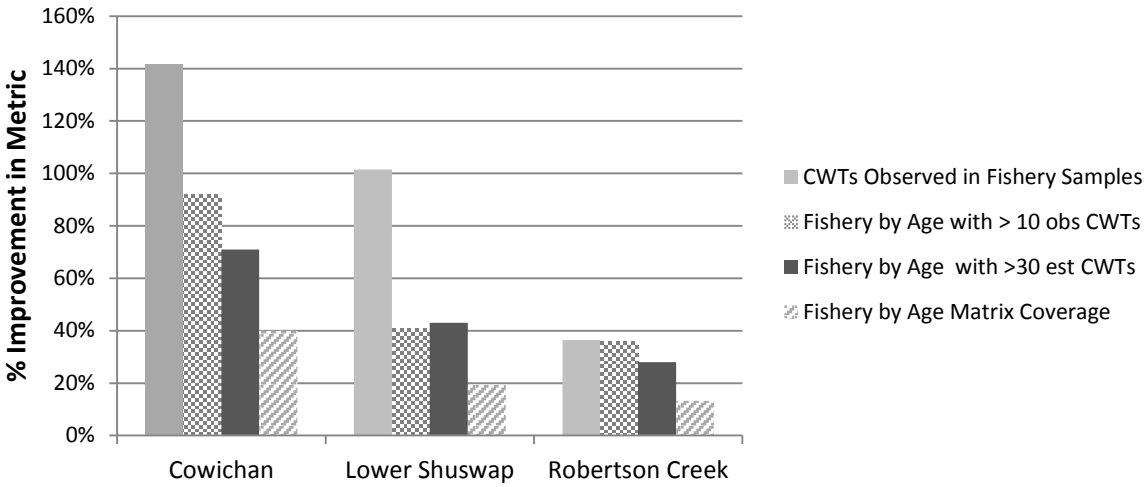


Figure 4.4 Percentage improvement in four key metrics calculated from fishery CWT recoveries attributable to CWTIP-funded projects for three Canadian CWT indicator stocks.

Metrics 2, 3, and 4 all describe spatial (and possibly temporal) improvements in the CWT recovery data. As total numbers of CWTs potentially available to be recovered was increased, the likelihood of recoveries in individual time and area stratum increased as well (metrics 3 and 4), as does the likelihood of recoveries of CWTs for multiple age cohorts in different fisheries (metric 2). As the CTC goals for fishery-specific recoveries of CWTs are a minimum of 10 observed and 30 estimated, these observed increases of 23-92% are notable. As expected, the Cowichan stock saw the greatest relative improvement in all three of these metrics, while Lower Shuswap and Robertson Creek saw increases of a smaller but similar magnitude.

Increase in precision of exploitation rate statistics was another anticipated result of the CWTIP funding and in general, as more CWTs are recovered in fisheries and escapement, estimates of exploitation rate are expected to become more precise. The CWTs estimated in fishery catches from broods available for all three indicators were used to calculate total brood exploitation rates. Following the methodology described in PSC (2005) the percent standard error (PSE) statistic for the brood year total exploitation rate (ER) was calculated as a measure of precision. For those broods with increased tagging funded by the CWTIP, ERs and the PSE were calculated for both the total CWTs recovered for a brood and for the CWTs recovered from the set of 'base'

CWTs. Mean values of PSE were then calculated for the total brood specific exploitation rate and the exploitation rate at the base tagging level. As precision improves with increased CWT recoveries, the PSE will decrease. The actual mean PSE values were compared as a metric of improvement. In addition, a metric of percentage change was calculated as with the previously described metrics. For this particular metric, a decrease (i.e., negative change) was expected. To convert the change to a positive value, the absolute value of the percentage change was taken. It must be noted that the PSE without CWTIP does not take into account improvements made due to sampling programs, which would undoubtedly have improved precision even more.

For Cowichan River, a 33% mean annual improvement in precision was achieved and was directly attributable to additional tagging (Table 4.2). For both Robertson Creek and Lower Shuswap River, mean annual improvements in precision were very similar. When expanding the scope to consider recent improvements in the context of historical results, it becomes apparent that the quality and precision of ER estimates have begun to approach those observed in the earlier years of the CWT program, particularly at Cowichan and Lower Shuswap where recent precision of ER estimates are nearing or at historic highs (Figure 4.5). Precision has been variable through time, but the improvements in the precision time series under CWTIP are striking.

Table 4.2 Improvements in precision of brood ERs expressed as percent standard error (PSE) for three indicator stocks resulting from increased CWT releases.
Data from broods 2007-2010 were used for the Cowichan River and the Lower Shuswap River stocks. Data from broods 2008-2010 were used for the Robertson Creek stock. The column heading 'PSE without CWTIP' refers to the mean PSE value calculated at the base tagging level. The column heading 'PSE with CWTIP' refers to the mean PSE value calculated for the total CWTs released (and recovered) for broods with increased tagging.

Stock	Mean Annual PSE without CWTIP	Mean Annual PSE with CWTIP	Relative Improvement in Precision of ER Estimate
Cowichan	13%	10%	**33%**
Lower Shuswap	26%	20%	**25%**
Robertson	23%	17%	**24%**

Given the conservation status of the Cowichan River and the WCVI stocks represented by Robertson Creek, their relative abundances can effect significant changes to mixed stock fisheries, particularly WCVI troll and northern BC (NBC) troll. In addition to the major fisheries that harvest these stocks, the increased spatial-temporal representation allows for greater resolution of fishery impact evaluation and stock distribution. These significant improvements are directly attributable to increased CWT application and will allow for more precise and effective management of these mixed stock fisheries.

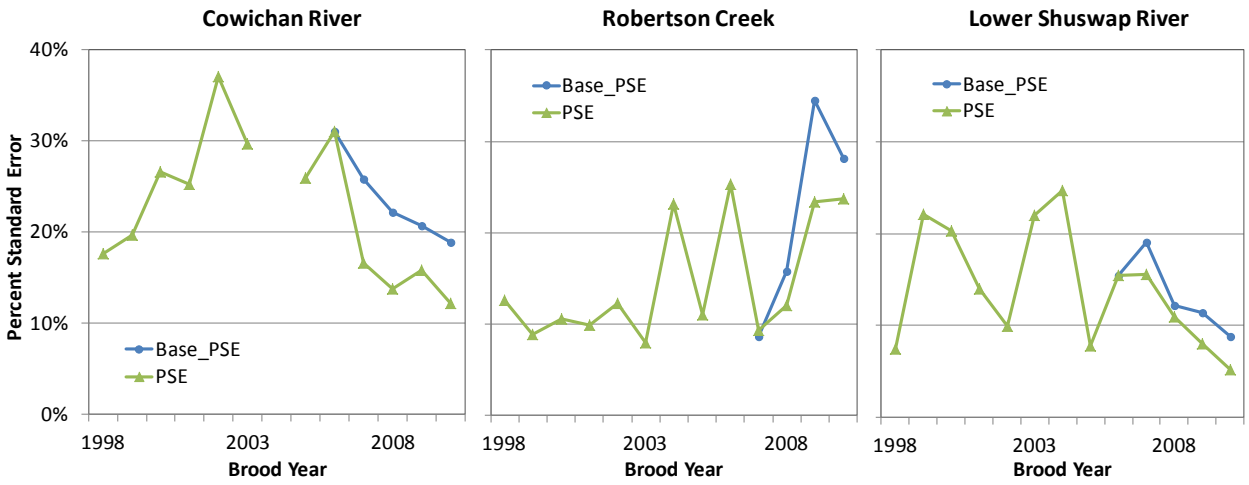


Figure 4.5 Time series of the percent standard error (PSE) associated with the total exploitation rates for three Canadian CWT indicator stocks for brood years 1998-2010.
The longer time series (triangle symbol) is the PSE calculated using all CWTs recovered for a brood. The shorter time series (circle symbol) represents the PSE calculated using CWTs arbitrarily chosen to represent the baseline level of tagging prior to incremental tagging with CWTIP funding. The divergence of the lines indicates the magnitude of improvement in the PSE with CWTIP funding. Note that there was no release of CWTs for the 2004 brood for the Cowichan River stock.

4.1.1.1.2 Atnarko Indicator Stock

The CWT Expert Panel Report (PSC 2005) identified a lack of indicator stocks representing central BC Chinook stocks (no indicator stocks on the BC mainland between the Skeena and Fraser Rivers). While escapement estimates for Atnarko have existed since 1950 and terminal run estimates since 1980, the estimates have not been standardized across different enumeration and estimation methods. The CWTIP provided an opportunity to augment existing tagging and escapement monitoring programs on the Atnarko River (Snootli Hatchery) to improve escapement estimates for early summer Chinook salmon.

The objectives of this project were: (1) to develop robust and defensible escapement estimates (meet PSC data standards) based on mark-recapture data; (2) to develop separate escapement estimates for males, females and jacks, hatchery and wild origin spawners; and (3) to calibrate the 1990-2013 historical escapement estimates for Atnarko Chinook based on these high-quality escapement estimates and data routinely collected using the historical methods.

CWTIP funding was used to augment the number of CWT fish released from the Snootli Hatchery, to increase sampling rates for CWTs in the spawning escapement and terminal fisheries, and to implement a mark-recapture program to generate an unbiased and precise estimate of escapement.

As a result of CWTIP funding accurate and precise estimates of Chinook escapement ranging from 9,000 to 20, 000 (mean PSE = 5.1%; Table 4.3) were achieved in years 2009-2014. CWT sampling rates averaged 19%. Terminal First Nation and commercial gillnet fisheries were sampled intensively, with respective mean sample rates of 86% and 45%. The mark-recapture program and the application of modern capture-recapture analytical approaches relying on

individual encounter histories and maximum likelihood estimators provided the necessary data to calibrate the historical time series of escapement.

An improved escapement time series is an important development that will improve planning of terminal fisheries, improve the accuracy of abundance indices and fishery planning for mixed-stocks fisheries in North and Central Coast BC (NCBC) and SEAK, and improve information to support First Nations Treaty negotiations.

Table 4.3 Maximum Likelihood Estimates of escapement based on individual encounter histories for Atnarko Chinook. Jacks are not included. Estimates and statistics represent the abundance of hatchery and wild fish combined.

	Males		Females		Total Adults	
Year	Escapement	PSE	Escapement	PSE	Escapement	PSE
2009	**4714**	**5.7%**	**4202**	**6.2%**	**8917**	**4.2%**
2010	4605	5.0%	4711	4.8%	9317	3.4%
2011	3761	9.6%	4321	8.6%	8082	6.4%
2012	2063	9.0%	2559	9.7%	4622	6.7%
2013	8433	5.9%	11529	7.5%	19962	5.0%
2014	8733	6.5%	10278	6.5%	19011	4.6%

4.1.1.1.3 Elk River Tagging and Terminal Sampling

The Elk River CWT release group represents a large geographic Chinook production area gap which is not currently accounted for in PST management. At the far south end of the range of far-north migrating fall coastal Chinook, the Elk River stock is intercepted in fisheries in SEAK, NBC, Washington and Oregon troll fisheries, and to a lesser extent in fisheries off of the WCVI. Those CWT releases from the Elk River are used to model the potential impact of fisheries, catch distribution, marine survival and are used in forecasting expectations of escapement for stocks from the mid-Oregon coast. Those basins which are presumed to be represented by the Elk include the Umpqua, Coos-complex, Coquille and Sixes River basins. CWT releases and subsequent terminal recoveries have spanned from base-period years (1979-82) through current years, but have been jeopardized by recent budget constraints. CWTIP support has allowed for a fully functional CWT release group size (200k+) (Figure 4.6) and appropriate terminal area sampling to occur in spite of recent management resource austerity. The terminal sampling program has allowed for appropriate sampling of terminal troll, in-river sport, hatchery and spawning escapement recruitment.

Early investment into electronic data collection during the first years of CWTIT support has allowed for ongoing annual efficiencies in CWT data flow. An estimated 120 person hours are saved annually through the utilization of data loggers in this project alone. This efficiency is crucial for the functionality of the Elk River as a modeled indicator stock. Elk River Chinook salmon are the latest returning stock (continuing into February of the following return year of other stocks) that is proposed for inclusion in the PSC Chinook model, and data turnaround is a limiting factor in its application towards fisheries management.

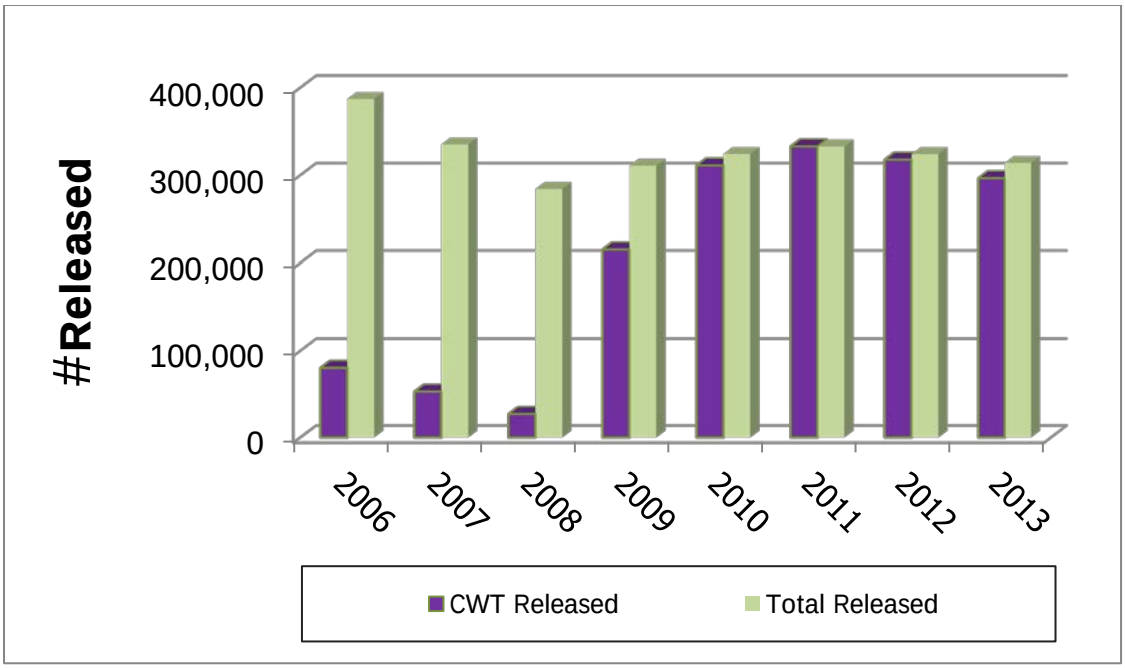


Figure 4.6 Elk River Chinook CWT release sizes from brood years 2006 through 2013. CWTIP funding supported incremental tagging in years 2010 to 2013. Total released includes CWT releases.

4.1.1.1.4 Chilkat Indicator

The Chilkat River Chinook salmon stock is a genetically unique, wild, CTC exploitation and escapement indicator stock located in Northern SEAK. It has been proposed as a PSC Chinook model stock by Alaska since 1999. Mature adults return in the spring and the progeny emigrate as yearling smolt. Harvests occur primarily in SEAK commercial troll and gillnet fisheries, and sport and subsistence fisheries.

Funds from the CWTIP have helped improve the stock assessment of this stock by adding/maintaining a CWT component. Estimation of escapement (in total and by age), harvest sampling and CWT processing are funded by other sources. Without the CWT component, only 2 of the 15 population parameters in Table 4.4 can be estimated; most of which are required for a CTC indicator or model stock. The CWTIP supplement has boosted mark fractions and increased precision in production and harvest estimates. This CWT program marks Chilkat Chinook juveniles in the fall (CWTIP funding) and smolts from the same brood year the following spring. Conducting two separate CWT projects on the same brood produces estimates of fall juvenile abundance (avg. = 487, 982), spring smolt abundance (avg. = 172,624), and estimates of overwinter survival, which has averaged 36.7%. The Chilkat CWT project is one of two projects in North America for Chinook salmon that produces estimates of overwinter survival for freshwater rearing. Escapement estimates of large Chinook (3- to 5-ocean age) have been precise (avg. 3,715, avg. PSE = 14%, which meets CTC precision standards for escapement estimates). The average CWT sampling rate in the escapement is 24.3%, and the overall CWT marked rate has averaged 9.0% per brood year (BY).

CWTIP funds have improved the precision of CWT harvest estimation in mixed stock fisheries, and brood year exploitation has averaged 19.4% (PSE = 22%). These data are an increasingly important tool used in SEAK fishery management and the PSC. Without the CWT component,

an indicator stock is simply an escapement indicator stock that does not allow analysts to evaluate fishery impacts.

Table 4.4 Stock parameters that can be estimated for the Chilkat River wild Chinook population with and without tagging and release of coded wire tagged fish.

Parameter	Without CWTs	WITH CWTs	Average Estimate (average PSE)[1]
Escapement	Yes	Yes	3,715 (14%)
Escapement by age	Yes	Yes	available
BY CWT marked rate	NO	Yes	9.0% (1%)
Fall fry production	NO	Yes	487,982 (16%)
Smolt production	NO	Yes	172,624 (22%)
Overwinter survival	NO	Yes	36.7% (26%)
Catch	NO	Yes	896 (23%)
Catch distribution	NO	Yes	Available
Incidental fishing mortality	NO	Yes	Provided in CTC reports
Total fishing mortality	NO	Yes	Provided in CTC reports
Total exploitation rate	NO	Yes	19.4% (22%)
Exploitation rate by fishery	NO	Yes	Available
Total adult production	NO	Yes	4,602 (12%)
Maturation rates	NO	Yes	Available
Marine Survival	NO	Yes	3.0% (24%)

[1] PSE is the (SE/estimate) x 100, aka the percent SE.

4.1.2 Fishery Catch and Sampling

The columns to the right of the heavy vertical lines in Figures 3.1 and 3.2 relate to regional fishery sampling for recovery of CWTs from indicator stocks. Issues relating to fishery sampling as reported in TR 25 and those resulting from CWTIP projects are graphically compared in Figure 4.7. Sampling has been improved in mixed stock marine fisheries, with 27% red colored cells (before CWTIP) reduced to 0% as a result of 5-years of CWTIP funding.

Recoveries of CWTs provide information about fishery impacts on indicator stocks. Sampling programs for mixed stock fisheries affect recoveries of many CWT groups simultaneously. Consequently, a large percentage of CWTIP funding was devoted to projects that improved aspects of tag recovery efforts in marine commercial and sport fisheries. Projects included, but were not limited to increasing sampling rates in fisheries through improvements in staffing and equipment, funding sampling programs that lost previous revenue sources, and investigating the use of auxiliary data in estimating tag recoveries in small fisheries (Table 4.5). Examples of projects that improved fishery sampling are described below.

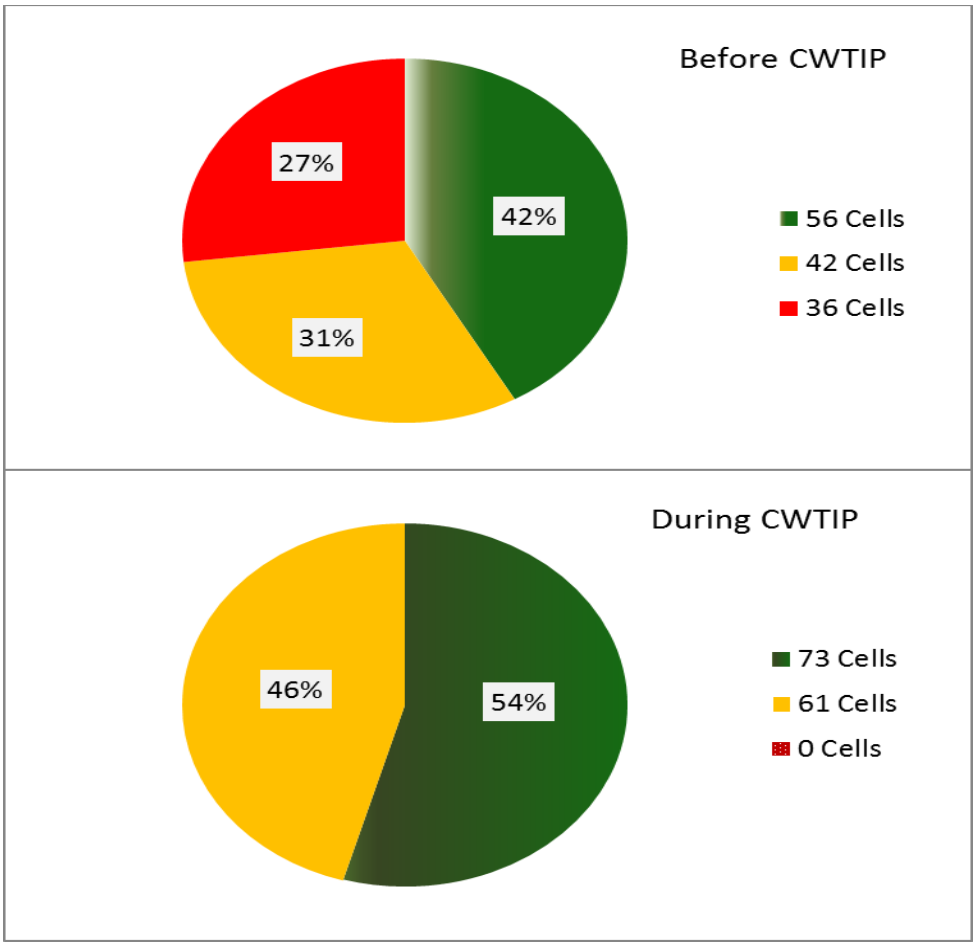


Figure 4.7 The estimated percentage and number of mixed stock fishery cells that were green, yellow or red in Figure 3.1 prior to CWTIP (upper chart) and Figure 3.2 during CWTIP (lower chart), of the 134 total colored cells for mixed stock fisheries.

Of the 12 CWT tagging and sampling issues listed in section 7.1 of TR 25, 9 refer to sampling issues in both catch and escapement. Fishery specific sampling issues included:

1. Sampling rates in terminal fisheries.
2. Uncertainty of catch estimates in terminal fisheries.
3. Sampling rates in highly mixed stock fisheries.
4. Uncertainty of catch estimates in terminal fisheries.
5. Non-representative sampling.
6. Incomplete coverage of fisheries
7. Voluntary sport fishery sampling programs
8. Need of sampling methods to facilitate mark selective fishery (MSF) evaluation and processing of CWTs.

CWTIP funding was directed at addressing fishery sampling issues that were prioritized in TR 25 by region. For example, through CWTIP funded projects, sampling rates in the SEAK Troll, Sport and net fisheries increased above the required 20% rate. CWTIP funding was used to purchase equipment to help resolve some issues of CWT recovery relating to mass marking,

address issues of non-representative sampling, and improve information available to assess MSF impacts. However, for these improvements to be sustained, consistent funding will be required.

Table 4.5 Improvements and maintenance of fishery catch and sampling programs resulting from CWTIP funding.

Fishery	Jurisdiction	Project Improvements and Maintenance
SEAK Troll	AK	Increased sample rates in troll fishery from 29% in 2003-2007 to 35% from 2010-2013.
SEAK Sport	AK	Increased sample rates from 15-16% in 2008-09 to 18% in 2013 and 2014, with peak sampling rates of 22-23% in 2011-2012.
SEAK Net	AK	Increased sample rates in seine and gillnet fisheries from a mean of 19% in 2009 to a mean of 32% in 2014.
NCBC Troll	Canada	Improved representative freezer troll fleet sample acquisition meeting DFO quality control standards – increased sample rates from 8% in 2000-2003 period to 21% in 2010-2013 period.
NCBC Sport	Canada	Increased sample rates for Haida Gwaii (HG) sport fishery from 13% in 2000-2004 period to 46% in 2010-2012 period.
WCVI Troll		Maintained a sample rate of 20-25% in Commercial troll fishery from 2009-2013 and implemented new T'aaq-wiihak First Nations fishery in 2 sampling in 2012 and 2013.
WCVI Sport	Canada	Increased peak fishery average sample rates from 12% in 2000-2004 period to 25% in 2010-2013 period and more than tripled the total number of recoveries of CWTs.
Georgia Strait Sport	Canada	Increased peak fishery average sample rates for Georgia Strait North sport fishery from 3129% in 2000-2004 period to 33% in 2010-2013 period. Increased sample rates for Georgia Strait South sport fishery from 14% in 2000-2004 period to 23% in 2010-2013 period. Increased sample rates for Juan de Fuca sport fishery from 21% in 2000-2004 period to 16% in 2010-2013 period. While sample rates were lower in Juan de Fuca, there was a minimum of 40% increase in the average number of CWTs recovered per year across all 3 Georgia Strait Sport Fishery areas.
WA Ocean Troll	WA	Maintained sample rate above minimum goal of 20% in non-Treaty troll fishery from 2010-2014.
WA Ocean Tribal	WA	Makah Fisheries utilized CWTIP funding to purchase a tag reading microscope and other related sampling supplies and staff time to maintain sampling rates of 35-40% in the summer troll fishery. In 2014, ~4,200 heads with CWTs

Fishery	Jurisdiction	Project Improvements and Maintenance
		were processed by the Makah.
WA Ocean Sport	WA	Maintained sample rate above minimum goal of 20% and maintained full spatial and temporal coverage in ocean sport fishery from 2010-2014.
Puget Sound Sport	WA	Legacy project to develop guidance for using indirect estimation techniques to estimate the numbers of harvested CWTed fish in freshwater fisheries.
OR Coastal Troll	OR	Maintained annual sample rates of at least 20% for all management areas from 2011-2014, except Tillamook in 2012 and Brookings in 2014 (both exceptions only slightly below).
OR Coastal Sport	OR	Maintained annual sample rates of at least 20% for all sampled ports from 2011-2014.

4.1.3 Examples of CWT Improvements in Marine Fishery Sampling

4.1.3.1 Washington Coast Troll and Sport Sampling

The CWTIP funded a portion of the sampling program in Washington ocean salmon fisheries replacing support formerly covered under the US Anadromous Fish Conservation Act. The CWTIP funding in combination with money from other sources, including the state General Fund, provided the resources for the Washington Department of Fish and Wildlife to maintain or exceed sample rate objectives in these fisheries. Without CWTIP funding that contributed an average of about 32% of the total sampling program, the sampling rates in these fisheries would be significantly lower and the sampling rate objective of at least 20 percent in each port sampling strata would not be achieved (TR 25; Issue 7-Low Sampling Rates in Highly Mixed Stock Fisheries). CWTIP funding for this program began in Fiscal Year 2011 and has continued through 2014, the final year of US CWTIP funding, at an average level of about $325,000 per year.

Support from CWTIP covered the staffing levels needed to assign field crews to sample at all ports throughout the season. Without CWTIP funding, it is likely that sampling staff would be shifted towards those ports and time periods with the highest landings and some sites/periods would not be sampled. Hence, a potential bias in the overall CWT recovery distribution along the coast could occur and would not properly reflect the coast wide impacts on indicator stock groups.

4.1.3.2 Oregon Ocean Troll and Sport Sampling with Electronic Detection

Beginning in 2011, full electronic sampling has been successfully instituted in Oregon's oceanic sport and commercial Chinook fishery sampling programs. Troll sampling rates exceeding the 20% target have been maintained throughout most all sampled strata (save for exceptions in the Tillamook area in 2012 and Brookings in 2014), with sampling rates commonly exceeding 40% (Figure 4.8).

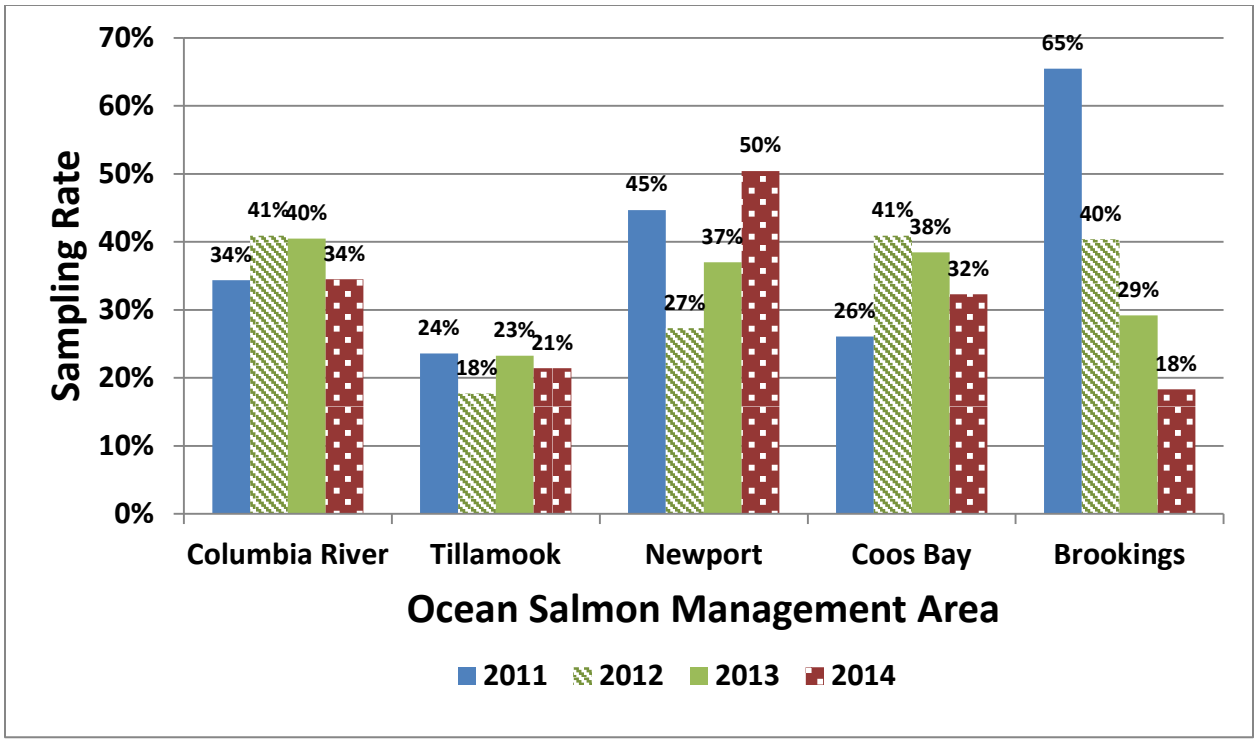


Figure 4.8 Sampling rate in the Chinook troll fishery by catch area from 2011 through 2014.

Ocean sport Chinook harvest sampling rates have been maintained at or above targets of 20% throughout the duration of the CWTIT program. Hundreds of unmarked CWTed Chinook have been sampled annually in both sport and commercial sectors which were previously not being electronically sampled. Unmarked Chinook have accounted for 10% of CWT recoveries from all Chinook in 2014, compared to 5% in 2013, 7% in 2012 and 13% in 2011. In the Columbia River catch area, 23% of those Chinook caught in 2014 would have gone unsampled compared to 17% of the catch in 2013, 13% in 2012 and 26% in 2011.

4.1.3.3 Canadian Troll Catch Sampling Rates

Prior to mass marking, visual sampling was used coast wide to recover CWTs. The de-sequestering of the adipose fin-clip has resulted in increased costs in electronic detection equipment and labour to process more fish to maintain a 20% sampling rate in BC fisheries. Figure 4.9 shows the catch sample rates achieved in the 15 year period from 1999-2014 in the South West Vancouver Island (SWVI) troll fishery relative to the proportions of fish with CWTs (i.e., tag rate) and with adipose fin clips (i.e., clip rate). Prior to mass marking of Chinook (2000), the catch sample rates were consistently over 20%. During this period, both the tag rate and the clip rate were approximately the same, and samplers handled and took heads from approximately 5% of the catch to recover the CWTs (clip rate = tag rate = ~ 5%).

Since 2000, mass marking has resulted in progressive and dramatic increases in clip rates in the SWVI troll fishery and commensurate increases in sampling effort to maintain catch sampling targets. Currently, approximately 50% of the Chinook catch is clipped and samplers take the heads from approximately 10% of the entire catch (clipped and unclipped) to recover the CWTs (clip rate = ~ 50%, tag rate = ~ 10%). Formerly, sampling effort required handling only the

tagged fish (the area in black in Figure 4.9). With mass marking, sampling effort requires the handling of all of the clipped fish from a vessel landing (visual sampling with electronic screening; the combined black and grey areas in Figure 4.9) to screen out fish that are clipped but not tagged. To acquire CWT data for double-index tag (DIT) groups, both clipped and unclipped, all of the catch from a vessel landing must be sampled using full electronic detection (the combined black, grey and white areas in Figure 4.9). DFO initially implemented full electronic detection in 2000 but did not have adequate resources to maintain the 20% catch sample rate without reducing sampling protocols to visual detection with electronic screening.

With the support of CWTIP funds in 2009, DFO returned to full electronic detection and maintained catch sample rates above the 20% level. With the end of CWTIP funding in 2013, again, DFO could not maintain the 20% catch sampling level and sampling protocols reverted to visual detection with electronic screening. The 2014 sampling rates in the SWVI troll were the lowest in this fishery since 1999 (Figure 4.9).

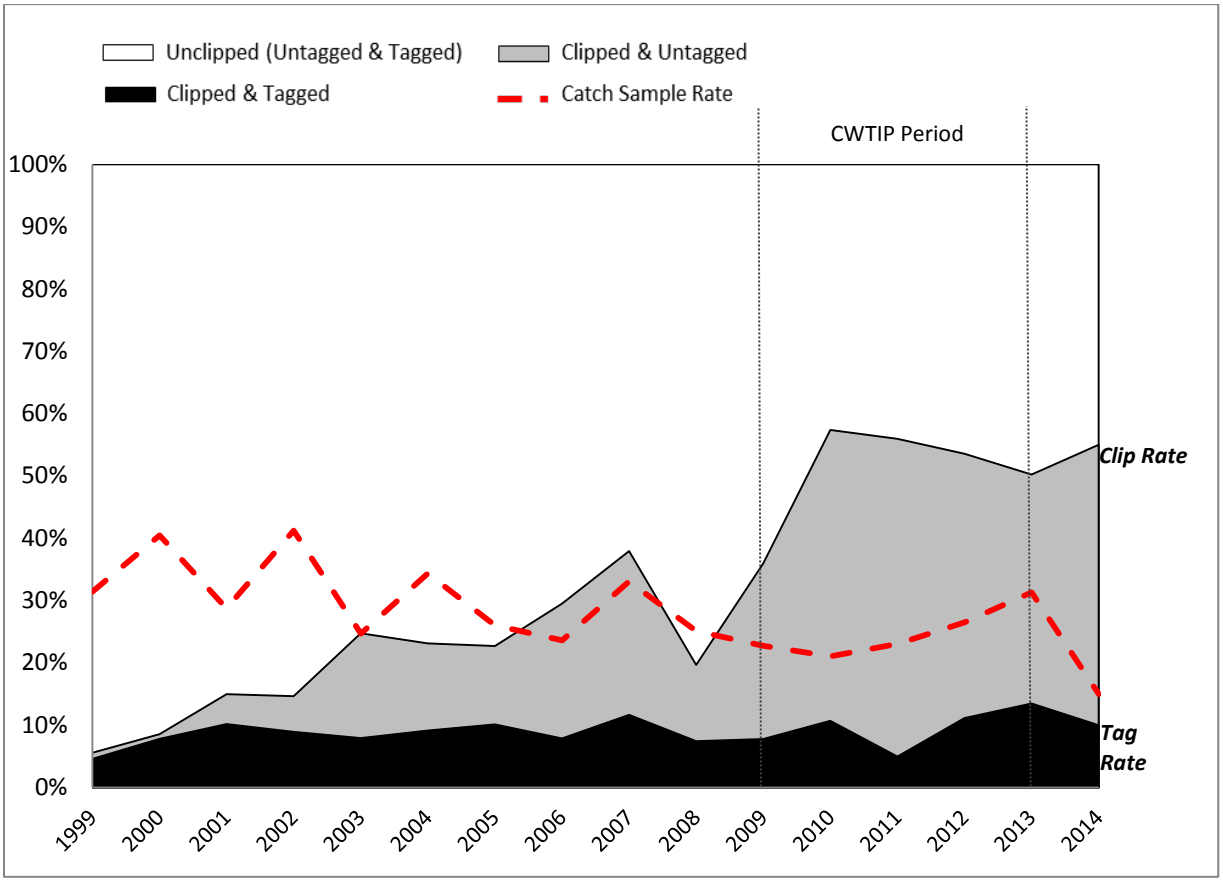


Figure 4.9 Temporal pattern in the catch sampling rate, clip rate and tag rate in the British Columbia SWVI troll fishery, 1999-2014, since the start of mass marking.
The black shaded area is the percentage of fish with an adipose fin clip and CWT (tag rate). The grey shaded area is the percentage with an adipose fin clip but no CWT. The combined black and grey areas represent the clip rate. The white area is the percentage of fish with an intact adipose fin (unclipped; tagged or untagged). All three areas sum to 100% for each year.

4.1.3.4 Lower Fraser Area First Nations Fisheries Sampling

The CWT Chinook Workgroup report (TR 25; PSC 2008) recommended that terminal native fisheries in BC should be sampled to produce statistically valid and representative CWT recoveries to improve precision of estimates of fishery impacts and cohort size. CWTIP funding from 2011-2013 supported collaborative work with the Lower Fraser Fisheries Alliance (LFFA) and DFO to hire seasonal technicians to provide education and technical support to 29 First Nation communities in the Lower Fraser Area (LFA). Funds were used to build the relationship between DFO and the LFFA and to support communication strategies to engage LFA First Nations communities to increase knowledge and awareness of the importance of CWT program and CWT sampling. Additionally, funding was used to aid First Nations monitoring organizations to implement changes and build tools to support random and representative CWT sampling and data collection to increase the number of head samples collected.

As displayed in Tables 4.6 and 4.7 below both the total number of samples and the temporal and spatial distribution of the samples collected for Chinook salmon continued to improve through the funding period. In addition, DFO and First Nations staff present on the fisheries observed

Table 4.6 Summary of Chinook head submissions by area from LFA First Nations Food, Social and Ceremonial fisheries, 2010-2013.

Area	2010		2011		2012		2013	
	#	%	#	%	#	%	#	%
Below Port Mann	0	0%	0	0%	2	9%	25	41%
Port Mann to Mission	0	0%	1	7%	2	9%	12	20%
Mission to Harrison	0	0%	1	7%	3	14%	8	13%
Harrison to Hope	7	88%	8	57%	5	23%	5	8%
Hope to Sawmill	1	13%	4	29%	10	45%	11	18%
Total:	***8***		***14***		***22***		***61***	

Table 4.7 Summary of Chinook head submissions by month from LFA First Nations Food, Social and Ceremonial fisheries, 2010-2013.

Month	2010		2011		2012		2013 *	
	#	%	#	%	#	%	#	%
April	-	0%	-	0%	-	0%	-	0%
May	-	0%	-	0%	-	0%	-	0%
June	8	100%	1	7%	1	5%	6	10%
July	-	0%	2	14%	14	64%	11	18%
August	-	0%	9	64%	7	32%	28	46%
September	-	0%	2	14%	-	0%	5	8%
October	-	0%	-	0%	-	0%	-	0%
Date Unknown	-	0%	-	0%	-	0%	11	18%
Total :	***8***		***14***		***22***		***61***	

***** *14 samples were submitted in 2013 without exact dates of capture.*

increased awareness of the program this season including multiple incidences of fishers having samples ready for collection by the sampler in advance of a prompt.

4.1.3.5 Haida Gwaii Sport Fishery Sampling

The CWTIP improved the quality and quantity of data for the Haida Gwaii (HG) sport fishery, which is the second largest sport fishery in BC and part of the NBC AABM fishery. First the quantity was increased by working with more fishing lodges to collect heads from adipose fin clipped Chinook and to ship them either to established Mark Recovery Program locations on HG or to Vancouver at the end of the fishing season. Also, the network of Head Depots and servicing was expanded to make it more convenient for non-lodge fishers to provide heads from adipose fin clipped Chinook. These efforts and the support by the lodges were extremely successful, with the submission rates increasing from an average of 11% during 2000-2004 to 43% during 2009-2012; CWT recoveries also quadrupled from an average of 142 per year (2000-2004) to 546 per year (2009-2012; Figure 4.10). About two thirds of the NCBC sport fishery catch is by HG sport fishery and the remainder is by ISBM sport fisheries in NBC, CBC, and Johnstone Strait. Education about the CWT program with the Haida Fisheries Program Creel Survey managers resulted in additional Chinook being examined for adipose fin clips and the mark rate data being reported regularly via in-season bulletins. Lastly, all the creel and lodge logbook data were reviewed from 1995 onward and then used to directly estimate CWT recoveries, whereas previously the average sample rates were used from South Coast ocean sport fisheries. The CWTIP funding was timely and coincided with the recent increase of mass marked far north migrating Chinook from Washington and Oregon based on the trends in adipose fin clipped Chinook with and without a CWT. Continued mass marking of Chinook by the southern US and higher submission rates will exacerbate the financial challenges with the sunset of the CWTIP in 2013-14.

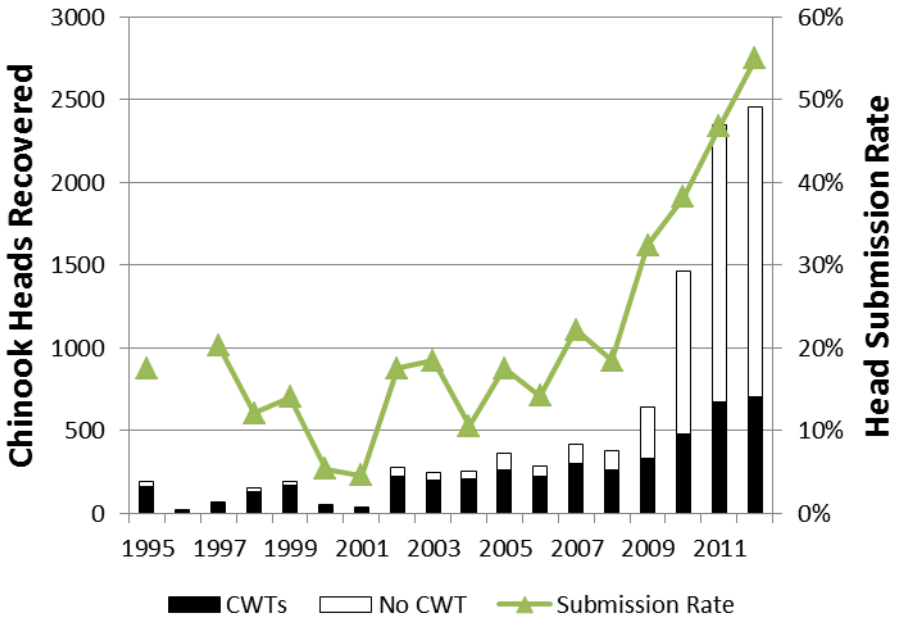


Figure 4.10 The number of Chinook heads and CWTs recovered from adipose-clipped fish and head submission rates for the Haida Gwaii sport fishery in the NBC AABM fishery, 1995-2012.

4.2 Legacy Items:

Since the CWT was first widely employed as a primary tool for salmon management in the 1970's, technology has changed dramatically. As a result, many agencies struggle to make do with equipment that has long passed its useful life and processing/reporting systems that were built piecemeal using equipment and computing platforms that are no longer in common use. Legacy projects involve investments in improving the infrastructure of the CWT system such as purchasing new equipment and integrating or updating CWT processing/reporting processes. These projects are expected to provide lasting benefits to the CWT System by reducing costs and/or improving efficiencies. In addition to the direct physical improvements, these projects can also produce benefits related to improved agency understanding, societal acceptance, and public cooperation in data collection processes. Examples of legacy projects are summarized below into four main categories: (1) Improvements in methodologies that provide more reliable estimates of CWT recoveries at reduced cost; (2) Equipment acquisition; (3) Information management improvements for data reporting systems and data collection; and (4) Project Planning.

4.2.1 Improvements in Methodologies

4.2.1.1 Puget Sound Freshwater Sport Sampling

Sampling even small sport fisheries in many terminal areas is resource intensive, and with shrinking funding to agencies for fishery management support, collecting data from these fisheries is a lower priority when compared with larger marine fisheries, or escapement sampling. Estimates of Chinook harvest from these fisheries are calculated from WDFW's catch record card (CRC) system, making creel sampling seem redundant. In TR 25, regional recommendations for inadequate sampling rates in terminal fisheries included analyzing and developing indirect methods for estimating tag recoveries in these fisheries (TR 25, pg 104). This project focused on developing indirect methods of estimating tag recoveries in terminal sport fisheries using harvest estimates from WDFW's CRC system, age composition of hatchery returns, and the tag proportion at release. These indirect estimates were paired with tag recoveries from intensive creel sampling that was funded by CWTIP to verify the indirect approach. The study was conducted in four mark selective Chinook fisheries occurring in freshwater terminal areas, including two smaller fisheries, Skagit River Spring and Skykomish Summer, and two larger fisheries targeting fall Chinook on the Nisqually and Skokomish Rivers.

Results of the study were mixed. Landed and kept catch estimates from the CRC data matched well with creel estimates in 2 out of 3 years for all four rivers. In the third year, estimates from direct sampling were lower than CRC estimates for the smaller fisheries, and higher for the larger fisheries. Tag sample rates were mostly above 20%, with the exception of the Skokomish Fall, and all fisheries used electronic tag detection for all landed fish. Differences in tag recoveries by age between the indirect estimation methods and expanded numbers from direct sampling were also mixed, with some age/fishery combinations having no statistical difference. There was no discernable pattern in the differences with regard to sample rates or size of fishery. Final recommendations on the use of indirect methods will be made by comparing estimates of CWT based harvest and exploitation rates using tag recoveries based on the two methods.

4.2.2 Equipment Purchases

The US spent $1,339,682 on projects that were primarily equipment purchases: including $1,110,316 for new electronic sampling T-wands coast wide, $144,712 for data loggers in SEAK, and $84,654 for CWT lab equipment. These expenditures primarily addressed the TR 25 issues of low sample rates (4,7), sampling to facilitate MSF evaluations (12), and timeliness of reporting (13).

Canada spent $340,900 for equipment purchases: including $94,000 for new electronic sampling T-wands, $94,000 for new CWT tube detectors and custom off-load sampling tables for commercial fishery sampling, $81,900 for CWT tagging equipment, and $33,000 for CWT lab equipment.

ADF&G estimated that the use of wand detectors would save about $700,000 by not having to process and ship heads from untagged clipped fish over the next 10 years while increasing sampling efficiency and rates and reducing handling of fish in processing facilities. ADF&G reports that the detectors eliminated the need to remove approximately 5600 heads from untagged clipped fish in the SEAK Troll fishery in 2013 (56%, in a year of lower than average catches). In addition to cost savings, this technology has improved relations with fish processors by reducing the need to handle fish and incur economic losses suffered in lucrative head-on markets.

Due to the prevalence of mass marked fish, it is now necessary to use electronic detection to identify fish that have CWTs. Even in fisheries that use visual sampling, electronic detection with wands or tubes can be used to identify which clipped fish actually have tags. The use of electronic detection has resulted in reduced costs, and increased efficiency and processor cooperation by reducing the number of heads without CWTs that are removed and shipped to the tag labs. The increased efficiency of sampling allows for improved sampling rates with equal or reduced staff time. The purchase of new electronic equipment was prioritized by the U.S. and Canada because new technology with improved detection range became available; it could be completed within the CWTIP timeframe, and would have long lasting benefits to the CWT program.

Data loggers were also purchased to improve efficiency and reduce future costs. By entering the data only once, in an electronic form on a data logger that can quickly be synced, efficiency is increased by drastically reducing staff time spent transcribing and manually entering data into electronic forms. Accuracy is also increased because the data loggers can incorporate immediate verification procedures, and electronic syncing eliminates transcription errors. There were additional data logger purchases within Information Management projects such as ODFW's Database upgrade project.

Equipment was also purchased to save time and money involved in processing tags at several tag labs, including replacing old scope based reading stations with camera based systems that can be used in conjunction with a monitor, purchasing new head coring machines that increase the speed of tag dissection, and improved storage facilities.

Improved efficiency due to the equipment purchases above also improves the timeliness of data being reported (TR 25, Issue 13).

4.2.2.1 Examples

Shortly after CWTIP funding was made available, a new "T-wand" was developed, with an increase in tag detection range from 3.2 cm to 5.5 cm. Previously large Chinook had to be scanned both externally and in the mouth. With the greater tag detection range, speed of

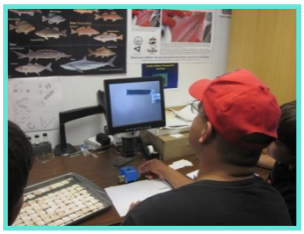
sampling is increased because mouth-wanding is no longer necessary, and tag recovery is improved because of fewer missed tags. CWTIP funds have purchased hundreds of new T-wand detectors. These wands have improved the efficiency and reliability of CWT recovery efforts while reducing costs for processing and transportation. The number of fish heads removed can be substantial. ADF&G reported (http://tagotoweb.adfg.state.ak.us/CWT/) that *"Since 1976, 128 million salmon were sampled in commercial, cost recovery, and sport fisheries and spawning grounds at 216 locations throughout Alaska. To date, 310,513 individual sampling events have been recorded on forms and entered into the database. 1.17 million heads weighing approximately 906.7 tons were removed from adipose clipped salmon and sent to the lab in Juneau for tag removal and decoding."*

In BC, custom offload tables and smaller portable custom offload tables were designed collaboratively with the fishery plant management to meet the requirements of the CWT sampling program to access 100% of the catch for each vessel, while respecting industry requirements for a minimal footprint at the site, high throughput, and careful handling of the catch to maintain economic value. Deployment of this new equipment has resulted in in long-term improvements to the sampling infrastructure and improvements in efficiency and reliability of CWT recoveries in the BC troll fishery catch monitoring program while reducing handling of fish.

Mass marking has increased the number of adipose-clipped fish which do not contain a CWT, requiring the removal and processing of fish heads that do not contain CWTs. The use of wands has eliminated the need to take heads from untagged clipped fish, reducing costs for processing and transportation.

CWTIP funds have supported the purchase of equipment to increase the efficiency of field operations. Field samplers can enter sampling and CWT recovery data into small field computers called data loggers for later electronic transmission (usually via internet) for validation and processing. Formerly, samplers reported data on paper forms then shipped them for electronic conversion. Data loggers speed up sampling, reduce data transcription errors, and provide users with faster access to CWT information for harvest management decisions.

CWTIP funds have purchased digital imaging system (DIS), consisting of a dissecting microscope equipped with a digital video camera and hi-resolution monitor for viewing and reading CWTs. Electronic microscopes have substantially reduced error rates and the time to decode CWTs while improving working conditions.



An electronic microscope purchased by the Makah Tribe has greatly increased the number of tags that can be read per shift and made the data available more quickly.

Old to New Dissecting microscope

4.2.3 Information Management

The CWTIP has supported several major projects to update and improve reporting and access to CWT data. As with hardware and equipment projects, the useful life and efficiency of CWT software are affected by changes in technology and computing platforms and limitations of institutional knowledge for system maintenance and development.

CWTIP Information management projects have improved the accuracy and completeness of historical CWT data since the 1970's and have provided tools to increase knowledge of information and the efficient access and use of CWT data for stock and fishery assessment. For example, the availability of historical data on specific location of an extracted CWT within the head of the fish has revealed an emerging problem with tagging. The size of CWT releases is increasing to compensate for reduced survivals and lower fishery harvest rates; inconsistency in tag placement within fish will affect the efficiency and suitability of equipment (e.g., tag detection procedures and equipment, corers) of future CWT recovery efforts.

In addition to increasing operational efficiency and reducing time lags and errors in data reporting, information management projects have enhanced agency staff understanding and coordination in the various components of the CWT system and identified opportunities for future improvements. Coupled with investments in equipment upgrades, investments in data management have substantially reduced the time required for data entry.

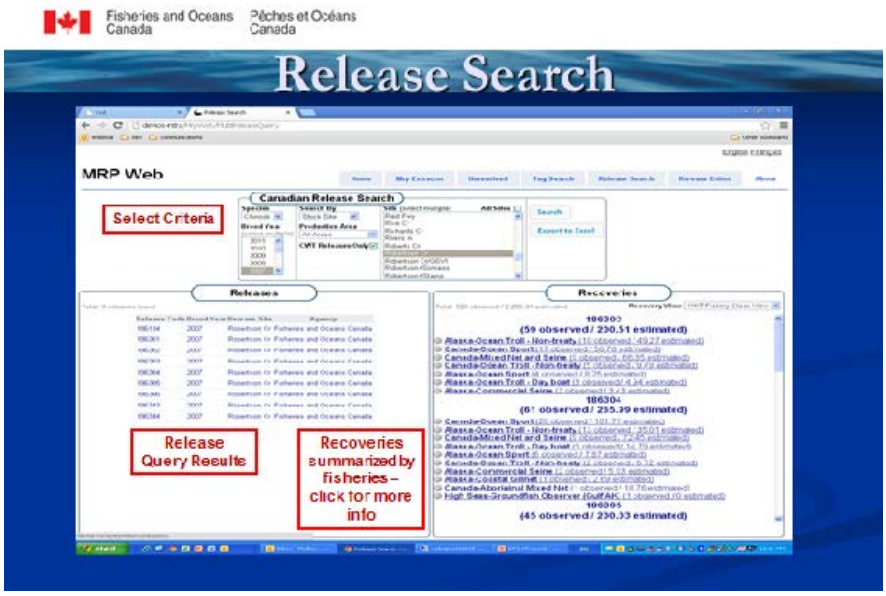
CWTIP-funded information management projects were undertaken in DFO, ODFW and WDFW to improve the consistency, timeliness, data retrieval and accuracy of CWT data reporting.

4.2.3.1Examples

4.2.3.1.1 DFO Database System Improvements

- DFO Salmonid Enhancement Program database project improved CWT data coordination and reporting procedures, and developed a formal set of Best Practices for the coordination (collection, transfer and management) of CWT heads and data at all DFO escapement projects. Archived escapement data from DFO enhancement programs were reviewed to ensure that standardized analytical techniques and data verification procedures have been employed.
- DFO has undertaken the review of the Mark Recovery Program legacy FORTRAN system and data, converting to current technology and improving interfaces within DFO reporting systems (hatcheries system, catch monitoring system, and escapement systems).

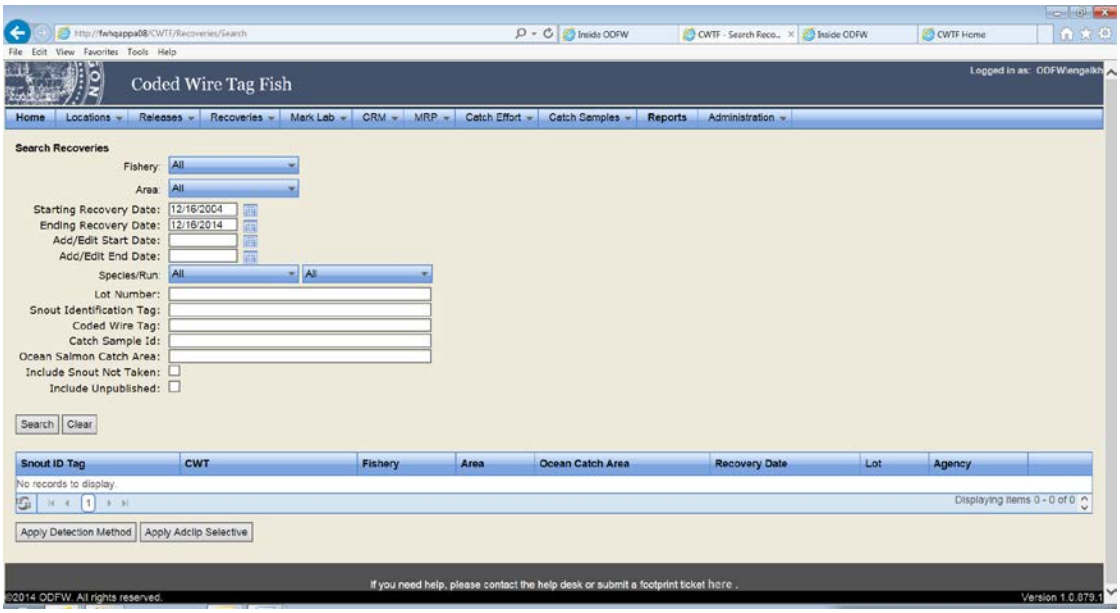
Projects include validation/correction of data and historical algorithms. A new web-based query interface provides faster, easier access to CWT data with many new features for all users, from beginner to advanced. These projects will provide lasting benefits for access to information and timeliness of data exchange to the Regional Mark Information System (RMIS).



- Improvements to the DFO Fisheries Operating System (FOS) commercial database. This project established standard protocols for commercial catch reporting (including test-fishing data) which will improve timeliness of reporting and availability of final commercial catch estimates.

4.2.3.1.2 ODFW CWT Database System Improvements

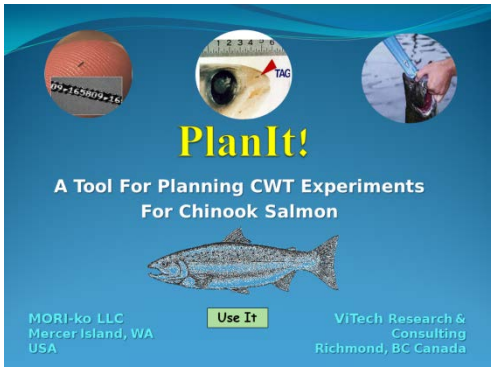
- ODFW's development of a new database application (CWTF) and support system for CWT data greatly improved the recording, reporting and accuracy of CWT data. The modern web-based relational application is easily accessible within ODFW through the internet enabling staff to access all records for CWT releases, recoveries and associated catch/sample data via easy to use query screens. A CWTF USER GUIDE developed under the project provides ODFW staff with access to an institutional knowledge base of CWTF programs, processes and calculations used to estimate CWT recoveries.
- Historical CWT data have been migrated to CWTF. Reports designed to meet needs of ODFW management staff can be downloaded in various formats such as MS Excel. Calculations of fishing effort and other metrics are generated by linkages to the Fish Ticket database (commercial landings), eliminating data entry and hand calculation errors.



Above: Screen shot of the CWT Recoveries search screen showing the various filters available.

- CWTF allows rapid validation of CWT data sets and expedites any necessary error corrections. Processes in reporting that formerly took several days to complete are now accomplished often in less than one hour. CWTF generates RMIS data files that are often validated on the first pass with few or no errors, increasing confidence in the accuracy of CWT data.
- For 2014, over 63,000 CWTs were recovered in ODFW sampled fisheries; almost twice the number in an average year. ODFW's Tag Recovery Lab would have been challenged to handle this increased workload without CWTF's capability to quickly verify and enter CWT recovery data.
- CWTIP funding enabled ODFW to purchase 50+ data loggers that directly upload recovery sampling data electronically to the CWTF application, eliminating time consuming, labor intensive and error prone steps previously done by hand.
- CWTF is designed with flexibility to rapidly accommodate changes in reporting requirements. For instance, new fisheries and recovery areas created by the 2014 Columbia River Fishery reforms were easily and quickly incorporated into CWTF.

4.2.4 CWT Project Planning



CWTIP funding was employed to develop a PC-based Decision-Theoretic Tool (PlanIt!) to facilitate planning of individual or multiple CWT improvement projects. PlanIt! provides a consistent framework for evaluating the impacts of projects on CWT statistics. Changes in survivals and fishery harvest rates have increased the complexity and difficulty of planning CWT experiments and programs. The CTC relies heavily on CWT-based

statistics for modeling, stock/fishery assessments, and evaluation of fishery regimes. The precision of CWT-based statistics (as reflected by coefficients of variation) depends on the number of CWTs recovered, which depend on factors such as release size, sampling rates, and estimates of catch/escapement estimation. PlanIt! enables a variety of questions to be addressed, such as:

- How many tags should be released to provide a desired level of precision about an estimate of stock-age-fishery exploitation rates?
- How will increasing the release size be expected to affect the uncertainty surrounding estimates of total exploitation rates?
- How will changes in a fishery sampling rate be expected to alter the precision about estimates of stock-age exploitation rates of CWT groups harvested by that fishery and CWT processing costs?
- How would improved estimates of catches or escapements affect the precision about estimates of exploitation rates?

5 Summary & Discussion

This 5-year summary report represents the CWTIT's synthesis of improvements to the CWT system for Chinook salmon. The improvements were undertaken as part of the 2009 Pacific Salmon Treaty (PST) Agreement for Chinook salmon in response to concerns raised by the CWT Expert Panel (PSC 2005) and CWT Workgroup (PSC 2008) regarding the ability to maintain a viable coast wide CWT system as required by a 1985 Memorandum of Understanding (MOU) between the United States and Canada. Under the MOU, the parties recognized the critical importance of maintaining a viable coast wide CWT system to implementation of the PST. The term "viable" was subsequently explicitly defined by the Ad Hoc Selective Fishery Evaluation Committee and the CWT Expert Panel as the ability to utilize CWT data to make reliable inferences on stock-age-fishery exploitation rates on natural stocks.

The PSC established the CWTIT to provide recommendations regarding the priorities for investing funding for improving the CWT system for Chinook salmon under the 2009 PST Agreement. Annually the CWTIT conducted reviews of project proposals and provided recommendations for funding to the PSC, and monitored and evaluated project results and the status of the CWT program. Over the course of the past five years, the Parties have implemented a number of short, intermediate, and legacy measures to improve the CWT system for Chinook salmon. The availability of CWTIP funding has also enabled continuation of important recovery programs that would otherwise have been lost due to the failure to appropriate funding support (e.g., Anadromous Fish Conservation Act grants in the US). Although not project related, the CWTIP has improved communication and collaboration among agencies. CWTIP workshops have provided opportunities for agency staff involved in all aspects of the CWT program (tagging, monitoring, analysis, data management, etc.) to share information and expertise to improve the CWT program through the exchange of information, discussion of issues, and experience. For these reasons, the CWTIT recommends that arrangements be made to continue annual reporting by CWTIT or another body with expertise within the PSC family.

Thirty years since the 1985 MOU was signed by the United States and Canada, the CWT still remains the primary tool that the PSC Chinook and Coho Technical Committees rely upon for regional modeling and stock/fishery assessments. CWT is also essential for regional management. The CWT system provides data that are exact to stock and age through coast wide standards for sampling and reporting. No other technology has been demonstrated to be capable of providing the coast wide data needed for PST and regional stock and fishery management. Programs to improve indicator stocks and sampling of fisheries and escapements over the short term have been implemented to address priority areas identified by the CWT Workgroup (PSC 2008; Figure 4-2). Long-term and legacy funded elements (e.g., equipment purchases, improvements to estimation, reporting, and planning programs) are expected to improve efficiencies and reduce costs for other elements of the CWT system for years to come.

Although methods such as parental based tagging (PBT) are being explored, such methods are not yet capable of replacing CWTs. A whole new system would need to be developed, implemented, agreed to and coordinated. It is clear that any alternative would cost more than the CWT system on an annual basis, most of the necessary components for an alternative are not in place, and a parallel process would have to be run for several years. In a time of increasing budgetary concerns, investigation of new technological approaches to provide data for salmon fishery management diverts monies that can be used to maintain the existing CWT program at necessary levels of tagging and recovery.

The CWTIT is concerned that fiscal pressures are seriously eroding the capacity of management agencies in both the US and Canada to perform basic stock and fishery assessments. Agency proposals to CWTIT covering a wide range of measures and activities normally attributed to standard assessment programs have surfaced in recent months. These have included projects designed to respond to the reduction or elimination of tagging, catch and escapement sampling and estimation programs, processing and reporting systems. Moreover, substantial support is sorely needed to improve the CWT system for Coho salmon. There is an economy of scale to maintain one program for both species.

The substantial improvements to the coast wide CWT programs for Chinook cannot be maintained without continued financial support beyond the 5-year sunset of the CWT Improvement program. Although a detailed plan for continuation has not been developed, the cost of sustaining improvements to the CWT system for Chinook salmon is estimated to be approximately $1 to $1.5 million per year for both parties combined.

The CWTIT recommends that: (1) the PSC directly support efforts to fund some of these elements for Chinook and necessary improvements for Coho salmon through the northern and southern endowment funds of the PSC, the US 1996 Letter of Agreement (LOA), and appropriations processes; and (2) regular assessments of the ability of the CWT system to provide the information required for implementation of PST fishery regimes and to support future negotiations. This assessment could be provided by the CWTIT or by the PSC Chinook and Coho Technical Committees.

6 References

Johnson, J.K. 2004. Regional review of coded wire tagging of anadromous salmon and steelhead in northwest America. Paper updated from 1989 to current year 2004. http://www.psc.org/pubs/CWT/CWTWebPapers/SpecificForWorkshop/johnson2004.pdf

(PSC) Pacific Salmon Commission. 2005. Report of the Expert Panel on the Future of the Coded Wire Tag Program for Pacific Salmon. 300 p. PSC Tech. Rep. No.18, November 2005. http://www.psc.org/pubs/CWT/EPfinalreport.pdf

(PSC) Pacific Salmon Commission. 2008, An Action Plan in Response to Coded Wire Tag (CWT) Expert Panel Recommendations. A Report of the Pacific Salmon Commission CWT Workgroup. 171 p. PSC Tech. Rep. No. 25, March 2008. http://www.psc.org/pubs/psctr25.pdf

Appendix A Terms of Reference for the CWT Implementation Team (CWTIT)

Pacific Salmon Commission:
Bilateral Approach to Implementation of Improvements to the Coast-wide Coded Wire Tagging (CWT) Program
November 13, 2009

Background. The Chinook chapter of Annex IV of the Pacific Salmon Treaty in place starting January 1, 2009, provides in paragraph 3(b) as follows:

> The Parties agree to provide $7.5 million each in their respective currencies (subject to the availability of funds) to implement over a five year period beginning no later than 2010 within their respective jurisdictions critical improvements to the coast-wide coded wire tagging program operated by their respective management agencies. The Commission shall select a bilateral body to recommend funding of specific action items identified in the Pacific Salmon Commission Technical Report Number 25 that are priority uses of these funds to improve the precision and accuracy of statistics such as abundance, exploitation rates, survival estimates, etc. for Chinook salmon used by the CTC in support of this Chapter.

Pursuant to the above, the Commission in February of 2009 agreed to a general approach to implement improvements in the CWT program. In October of 2009, the Commission discussed again how to implement the program, empanelled a group of technical experts to provide recommendations, and provided a schedule for completion of initial tasks. This document incorporates the approach agreed to in February of 2009 while adding the specific tasks and schedules agreed to in October of 2009.

Technical team. Each Party identified to the Commission its respective members for the bilateral body that will be tasked with identifying and recommending to the Commission how each Party should utilize the funds provided pursuant to Paragraph 3(b). This body draws its members largely from the CWT Working Group (who authored PSC Technical Report 25) and will be referred to as the CWT Implementation Team (CWTIT). The initial membership list of the CWTIT is attached.

Commission oversight. Each Party will identify one or two PSC Commissioners or other senior official to oversee the activities of the CWTIT.

Purpose of the CWTIT. The fundamental purpose of the CWTIT is to provide recommendations to the Commission and the Parties on use of the funding provided under the new agreement to support specific actions identified in the Pacific Salmon Commission Technical Report Number 25. These actions will improve the precision and accuracy of statistics used by the Chinook Technical Committee (CTC) in support of the Chinook agreement. Consistent with this purpose, the Commission agrees as follows:

- Due to the interconnected nature of the coast wide CWT program, the benefits of the CWT programs operated in the various jurisdictions can be optimized and synergies identified through proper coordination and planning, for example by ensuring that improvements in

tagging programs in one jurisdiction are associated with complementary changes that may be needed in sampling programs in other jurisdictions.

- While it is recognized that each Party retains the final discretion as to how to use its fiscal resources, the goal of this coordinated bilateral effort is to improve the precision and accuracy of aspects of the coast wide CWT program for the purpose of better implementing the agreed Chinook management regime.

Initial Tasks for the CWTIT. The following tasks and schedules are provided to guide the work of the CWTIT:

1. Review PSC Technical Report Number 25 guidelines and recommendations and identify specific prioritized recommendations based on technical and cost considerations as to how specific programs should be initiated, modified, expanded or otherwise changed to improve the precision and accuracy of identified aspects of the CWT program. In this context, "specific recommendations" includes identifying which agency or entity should implement the recommended measures, as well as the incremental costs involved. The recommendations should be developed with consideration given and reported as to the duration of funding required and implications for on-going and/or future costs. For example, if tagging of an indicator stock is increased then the costs of tag recovery may be incrementally increased when tagged broods are vulnerable to fishing and return to spawn.

2. To facilitate effective implementation of the program, the CWTIT should seek review by agencies affected by the recommendations. The agencies that would implement recommendations should be asked to provide comments and suggestions on the draft recommendations. While the agencies are likely to have members on the CWTIT, it is appropriate for the agencies to review the recommendations to provide additional insight for consideration by the Commission and Parties. For example, assigning appropriate costs to changes in programs may invoke different kinds of expertise than the task of identifying the extent to which the change may address statistical objectives.

3. Recognizing that Canada's appropriations process enabled starting its CWT program improvements prior to the point at which the United States will secure its initial funding increment, the U.S. members of the CWTIT should review the initial list of actions funded by Canada in 2009 and, if necessary, seek clarification from Canadian members to understand the rationale underlying Canada's decisions. If the U.S. members identify any significant potential concerns with respect to Canada's initial program focus, those should be reported to Commission through the U.S. Section.

4. The CWTIT will report its recommendations to the Commission, with supporting rationale, in a format and content that will facilitate deliberation by the Commission, mindful of the need of the Commission to inform affected agencies and justify its recommendations.

Schedule. To facilitate decisions as to use and specific distribution of funds in 2010, the Commission requests that the report referred to in Paragraph 4 be presented in draft form to the Commission at its January, 2010 meeting and finalized for the February 2010 Annual Meeting.

Refinements of future tasks and associated schedules will be developed at the February 2010 meeting and thereafter as appropriate.

CWT Implementation Team Members [1]

U.S. members:

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Ken Johnson, ODFW
Larrie LaVoy, NOAA Fisheries
Mike Matylewich, CRITFC
Scott McPherson, ADFG (co-chair)
Gary Morishima, QIN
Kristen Ryding, WDFW

Canadian members:

Gayle Brown, DFO
Roberta Cook, DFO
Chuck Parken, DFO
Arlene Tomkins, DFO (co-chair)
Howie Wright, ONA

Commissioner / agency oversight

United States Section:	David Bedford, Larry Rutter
Canadian Section:	Dr. Laura Richards

[1] The membership list was subsequently modified as reflected on this report's membership list.